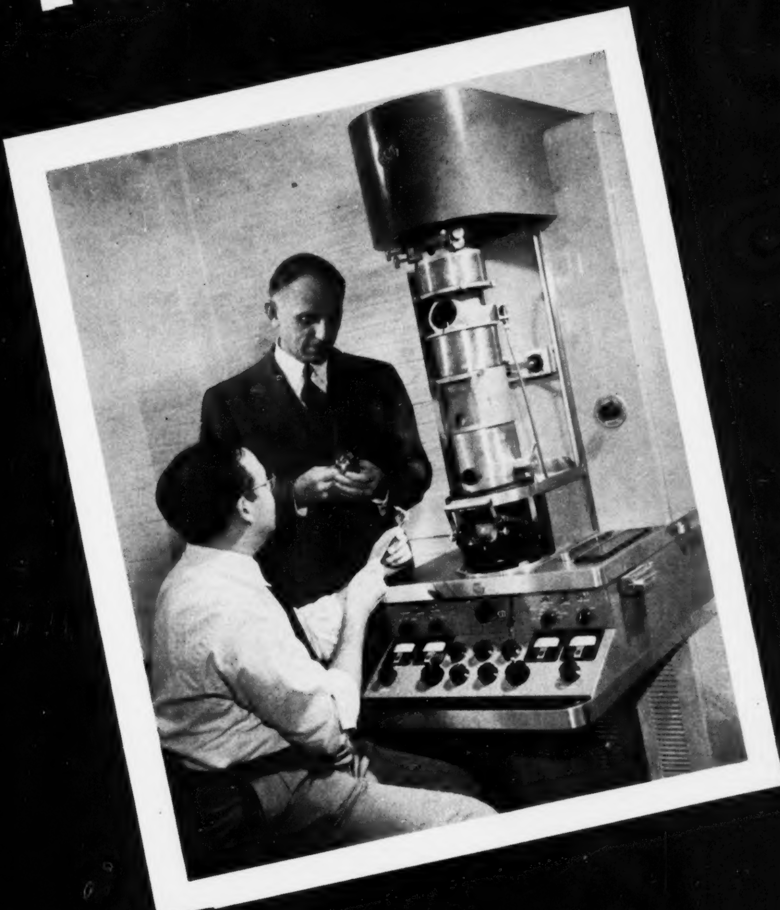
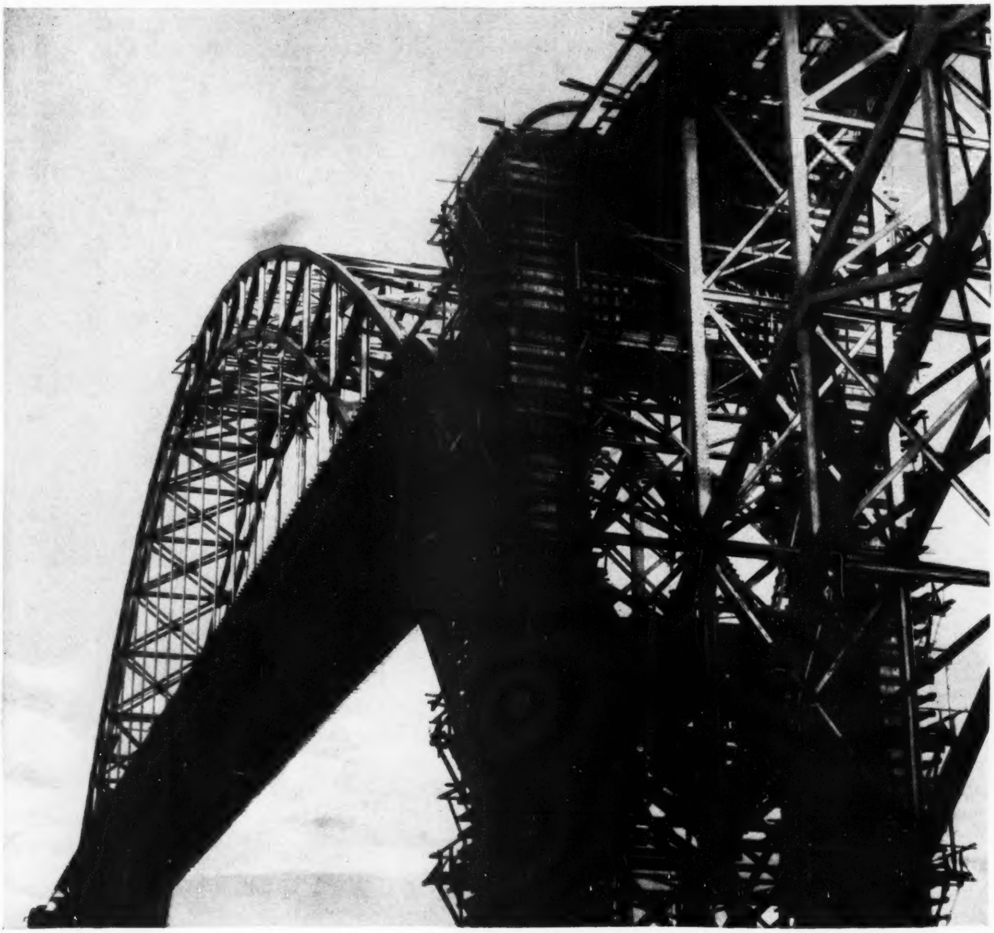
THE CORNELL ENGINEER



COLLEGE OF ENGINEERING · CORNELL UNIVERSITY

Cross a bridge and make a wish



NEXT time you cut ten or twenty or fifty miles off a weekend trip home by taking the short way over a bridge—give a thought to the days when the bridge wasn't there, when people *had* to take the long way around.

Right then would be a good time to make your wish . . . a wish that you will soon be able to put your engineering knowledge to work in helping to plan and build the things that make America great.

The steel industry offers hundreds of possibilities in this direction. From the mining of raw ore to the fabrication of the finished product, steel-making is directed by technically-trained men. Specialists in every phase of engineering play a vital role in the many and varied steps in making steel. Thousands of other engineers supervise the transformation of finished steel into structures like this mighty bridge.

United States Steel recognizes the need for carefully-trained specialists and pays particular attention in its educational program to the development of college graduates and other technically-trained men. This program has as fundamental objectives providing employees a sound foundation for advancement and assuring them opportunity for maximum personal development.

The training program in United States Steel has become the "bridge" to successful careers for hundreds of capable young men.

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UNITED STATES STEEL

Founded 1885

The CORNELL ENGINEER

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COVER: Professor Lloyd P. Smith and Professor Benjamin M. Siegel inspecting specimen holder of electron microscope at the Cornell electron microscopy laboratory.
—*Courtesy Sol Goldberg*

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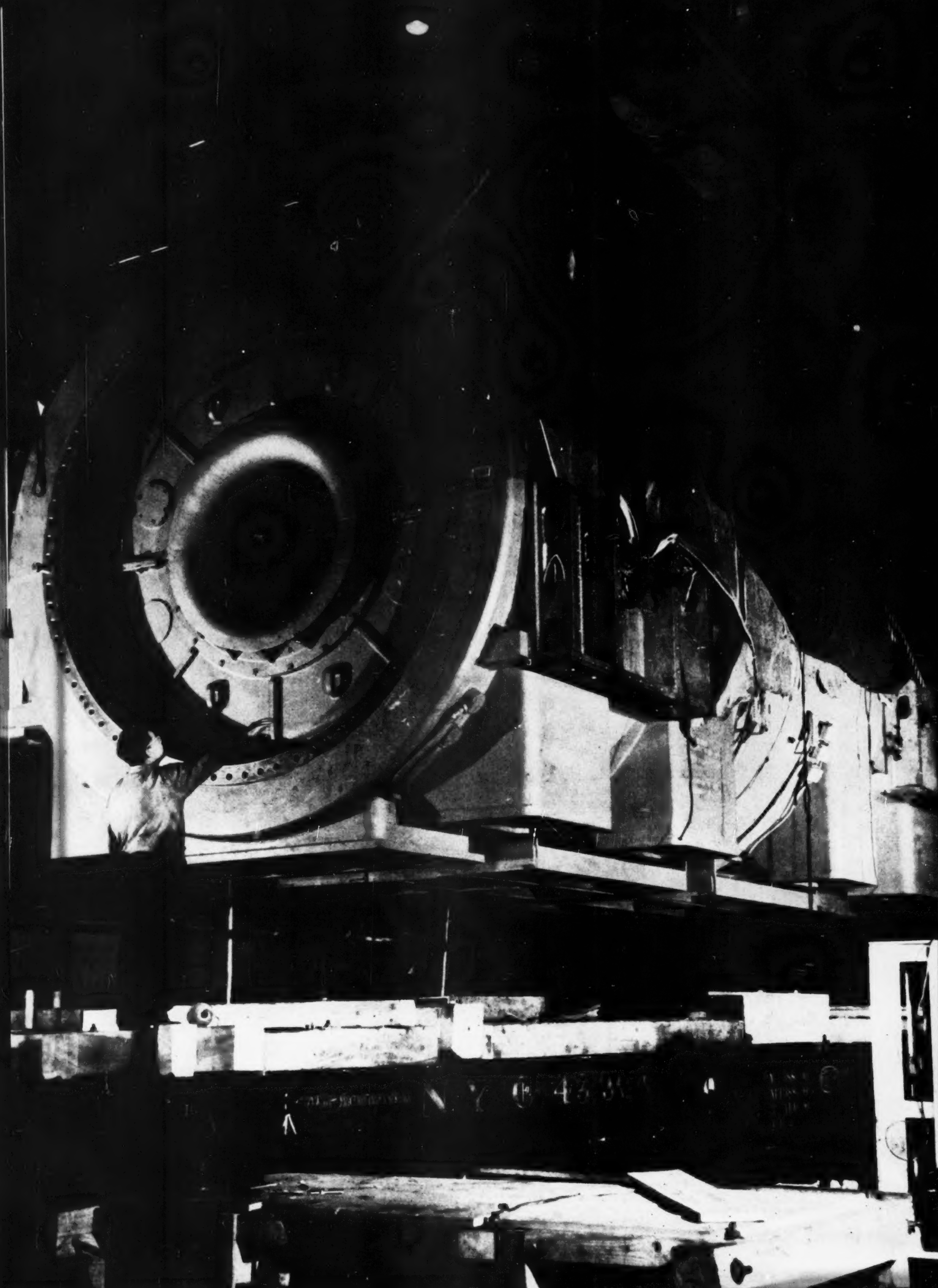


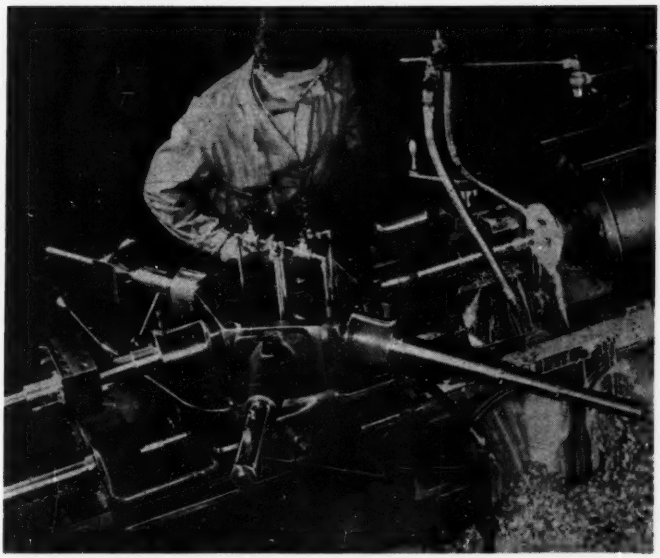
—Machine Tools Today—

By TELL BERNA, M.E. '12

Photographs courtesy the Author

THE majority of machine tools in use in the manufacturing plants of the United States are obsolete and their performance is far behind modern standards of productivity.

This situation, an old story to builders of machine tools, is statistically confirmed in the recently concluded Survey of Metalworking Production Equipment conducted by the *American Machinist* which shows that over 43% of machine tools in use in the country today are over 10 years old, and 95% are more than 10 years old in design.



The Turret Lathe is one of the basic general purpose machine tools. The one shown above is tooled for six successive operations.

Past History Reviewed

It would seem incredible that a nation to which the rest of the world looks as the leader in production methods should have fallen so far behind in the actual utilization of new ways to make better things for more people at lower cost. To understand how this state of affairs came about, it is necessary to review past history; and this, in turn, will explain the status of the machine tool industry today.

Since machine tools are used to cut and shape metal into the working parts of practically every mechanical device using iron or steel —all the way from the smallest vacuum cleaner to the largest steel mill—they are essential to every phase of our industrial economy and constitute the major share of the productive equipment of the country.

The machine tool industry, however, is small by comparison to many other industries. It consists of some 250 companies scattered for the most part, through the territory north of the Ohio and east of the Mississippi. The typical company employs today from 150 to 200 people. In the prewar period from 1934 to 1938 inclusive, sales of the entire industry averaged only $121,600,000 per year.

Machine tools are just as essential to the building of the weapons of war as they are for the tools and the conveniences of peace. When war broke out in Europe, therefore, there was immediate need for machine tools for the Allies, which was followed by our own preparedness program and then our war program itself.

The speed of our war production program depended entirely upon the speed with which the machine tool industry could furnish the tools required to implement it. The

This 288,000-pound stator for a 150,000 kilowatt generator is shown being hoisted into place on a flat car ready for shipment. This piece of equipment is part of a steam turbine-generator that was constructed by G-E for the Commonwealth Edison Company of Chicago.
—Courtesy General Electric

Cutting a slot on the shank of a propellor blade, this vertical broaching machine is hydraulically operated.

industry forthwith plunged headlong into a war expansion program which pushed output and capacity to levels which, by comparison to past experience, were incredible. The peak was reached in 1942. In that year the industry's output totaled $1,320,000,000 by contrast with the 51-year prewar average of $121,600,000.

Effects of War

Under normal conditions, the machine tool industry is constantly redesigning its products in order to bring to American industry new, better, and more productive models. But with the impact of the war, there was no time for that. Changing models would slow down output. So as of 1940 all designs were frozen.

The end of the war found the machine tool industry in a serious predicament for the following reasons:

1. Unlike most types of war materiel, machine tools were not expendable. So, when peace was declared, the Government found itself in possession of vast quantities of used machine tools. These were offered for sale to American industry at bargain prices. The very machine tools, therefore, that the machine tool industry had built for war became its most serious competition when the war was over.
2. It takes time to design and perfect new models and put them on the market. There had been neither time nor manpower available for this during the war. So for some years after the close of the war, while machine tool builders were working on new postwar models, they still could offer as new machines, for the most part, only the same old models which they had been building during the war period.
3. Machine tool builders were in many cases without adequate resources to carry them properly through this difficult postwar period and adequately finance rapid development of new models, because renegotiation had deprived them of financial reserves.

By 1945 the industry's sales had dropped to $423,700,000. Figures for subsequent years are as follows:

Machine Tool Sales

1946	$334,800,000
1947	$306,000,000
1948	$288,450,000
1949 (est.)	$250,000,000

Table 1

By 1947, however, the industry as a whole had succeeded in getting a wide range of new models ready

THE AUTHOR

Tell Berna is a graduate of Cornell University, Class of 1912, with the degree of Mechanical Engineer. He has recently completed a term as Trustee of the University.

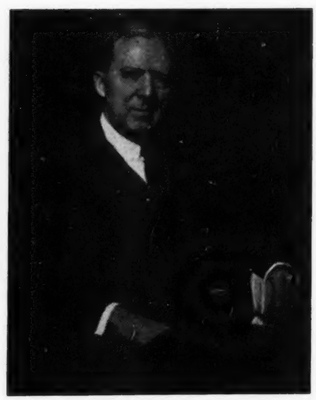
He received his first training in the electrical industry with the Cutler-Hammer Company, for whom he was a branch manager in Cincinnati for seven years.

His experience in the machine tool field covers some twenty-one years: successively as Sales Manager for the G. A. Gray Company, builders of planers in Cincinnati; General Sales Manager for Union Twist Drill Company of Athol, Massachusetts, manufacturers of cutting tools; and seven years as Sales Manager with the National Acme Company of Cleveland, manufacturers of multiple spindle automatic screw machines and die heads.

Since 1937 he has been General Manager of the National Machine Tool Builders' Association.

Mr. Berna's experience in the industry has given him a wide acquaintanceship in metal working plants throughout the country, particularly in New England and the Middle West. His work during the war and in postwar years has brought him closely in touch with the activities of the armed services and many other government agencies.

Tell Berna



for market. These models were displayed at the Machine Tool Show held that year in Chicago, where 12 acres of new models were put on display. Never before were so many, and such effective advances in the art of cutting metal exhibited for the benefit of American industry. A survey made on that occasion indicated that the new models showed an average increase in productivity of at least one-third over those of wartime design.

Factors Retarding Purchase

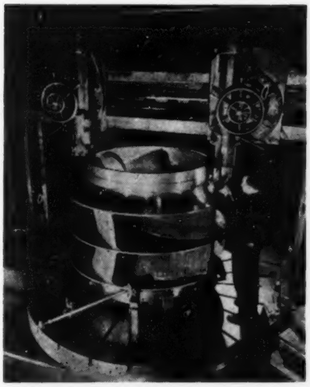
In spite of this fact, however, American industry has been slow to take advantage of these opportunities. In the main, the factors that have been retarding the purchase of new and better machine tools appear to be the following:

1. The over-all political and economic climate has not been favorable to the venture of "risk" capital. Machine tools represent an investment in the future. Companies have hesitated to invest in the future in view of threatened trends of dubious import to industrial progress.

2. The policy of the Internal Revenue Department with respect to depreciation allowances on machine tools has proved a definite and immediate barrier to their purchase. With redesign and improvement normally rapid in the machine tool industry, most machine tools may become obsolete in seven to ten years and it is doubtful whether any purchaser would estimate the probable profitable life of a new machine tool at longer than ten years. The Internal Revenue Department, however, insists on the average that the cost of a new machine tool may be recovered out of tax-free income only by spreading depreciation over at least period of 15 to 25 years.

A purchaser, therefore, can recover only one-half of the cost of the new machine during the ten years representing its profitable life. The other half of its cost, if recovered in this period, must come out of earnings. This means setting aside against the purchase of a new machine not only earnings representing half its cost but the Federal Income Tax assessed against that amount of earnings.

This situation means, in fact, that the Government is actually imposing a substantial tax upon the purchase of a new machine tool.



This Boring Mill is working on a 7 ton cast iron rotor for a generator. The huge part is rotated on a circular table while the cutters, one of which the operator is adjusting, are moved against it.

3. Leaders of organized labor in many cases, preached the philosophy of limiting actual output on new machine tools to a point far below their potential rate of productivity. This is done apparently under the delusion that increased productivity threatens jobs. This is a perfect example of upside-down economics. The history of our country shows that jobs increase, wages increase, and the standard of living rises in direct ratio to progressive mechanization. But some labor leaders are still preaching the mistaken doctrine of a century ago, that new machines, which cut costs and make products available to larger markets, decrease employment. Why should a manufacturer purchase a new machine if the shop steward gives orders to the operator to turn out no more production on the new machine than he formerly turned out on the old machine which the new one replaced?

The net effect of this situation upon the economy of the country is, to say the least, alarming.

With postwar shortages now filled, we have reached, in theory, the stage at which we should be able not only to control inflation but to resume our normal trend resulting from the principle of competition operating in a free economy. That trend has been one of greater abundance. Year by year, most people have gained more in return for their day's work than the year before. That is presumed to be "the American way"—so much envied by every other country in the world.

But the key to such progress remains, as always, increased productivity. And how can we secure increased productivity with such a large share of our productive equipment consisting of models that were

(Concluded on page 24)

In a planer the tool is stationary and the work piece is moved back and forth beneath it, while with the shaper illustrated below, the parts are held stationary while the tool is reciprocated. One important function of a shaper is contouring as shown.

NEW ROLE FOR
AN OLD MATERIAL

Prestressed Concrete

By WILLIAM HERSHELDER, C.E. '49

STANDING in a cold afternoon drizzle in Philadelphia on October 25, over 500 engineers representing twenty-seven states and four foreign nations watched a flanged prestressed concrete test girder 160 feet long, 6 feet 7 inches high, and 7 inches wide at the web being loaded to failure. The girder was built exactly similar to girders that are to be used for the main span of the new 300 foot Walnut Lane Bridge in Philadelphia.

What made this girder and this test notable was that the girder was for the first prestressed concrete bridge in the United States and it was the largest prestressed girder which has ever been tested. For the occasion, Professor Gustave Magnel, of the University of Ghent, Belgium, one of the pioneers in the development of prestressed concrete who has designed and engineered the construction of prestressed concrete bridges, factories, hangars and other structures in Europe, flew in from Ghent and supervised the test .

Superior Strength Characteristics

The girder did not fail that day. Loaded up to more than ten times the working load specified by Philadelphia engineers, it bent, cracked in a few places, and then with behavior characteristic of prestressed structures, the cracks *closed* when the load was removed at the end of the day. Finally, two days later, orders were given to terminate the test and the girder was destroyed under approximately 15 times the working load.

The visiting engineers were impressed. Trade periodicals carried prominent discussions of the test and its effect on the future of concrete design. Philadelphia and New York daily newspapers carried articles and photos and even the discerning Newsweek featured a discussion of the test under the title of "Stronger Concrete."

Civil engineers and architects who had followed the development of prestressed concrete in this country and Europe were not surprised. For many years prestressed concrete had been a structural curiosity, but immediately preceding the war new techniques had improved its use so that in many cases prestressed concrete could now compete favorably and undersell structures built with reinforced concrete. The Walnut Lane Bridge, by using a prestressed concrete design, will cost the City of Philadelphia $700,000. The next acceptable design, an arch bridge, of conventional reinforced concrete, would have cost $1,000,000. Perhaps more striking is the saving in circular water tank design. While a conventional reinforced concrete tank of 90 feet diameter and 20 feet height would require a 35″ wall, a prestressed concrete tank requires but 7″, representing a saving of more than 50% in concrete and 35% in steel.

Prestress Fundamentals

Prestressed concrete not only saves materials because it can be

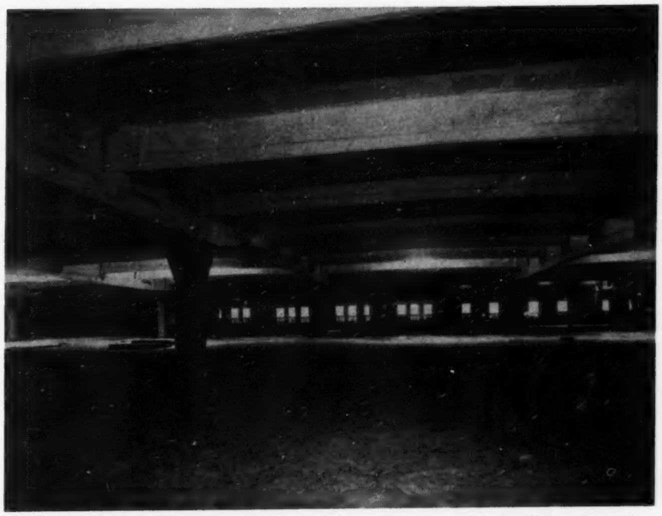
THE AUTHOR

Bill Hershleder, a civil engineer, graduated from Cornell in June, 1949 first in his class. He is a member of Chi Epsilon, the Debate Society, and Tau Epsilon Phi.

A native of Chicago, Illinois, he spent most of his early life in France where he lived before the war. Widely traveled in his youth, he is interested in visiting foreign countries and hopes to work in South America, where he feels there is a great future for engineering and prestressed concrete in particular.

He is now employed as an engineer by the Preload Corporation, builders of prestressed concrete structures.

Bill Hershleder



Interior view of textile mill at Ghent, Belgium, shows some of the 100 main girders and 600 secondary girders of prestressed concrete. Each main girder carries about 28 tons per linear feet and bridges a span of 72 feet. The girders were cast away from the site and lifted into position, eliminating extensive scaffolding that reinforced concrete construction would have required.

—Courtesy Preload Corp.

made stronger than conventional reinforced concrete, but it is also crackproof when subjected to design loading. Reinforced concrete is not crackproof. While plain concrete can withstand high compression it is so weak when subjected to tension that as soon as it begins to elongate slightly it cracks. In reinforced concrete, steel bars are placed in the tensile zones (see Figure 1) but cracks will still occur. The steel, which holds the beam together by assuming the entire tensile stress due to loading, will not assume these stresses until the concrete can no longer take any share of the tension and cracks.

The remedy to the weakness of concrete in tension is prestressed concrete. Anticipating the tensile forces that will act on the concrete beam once it is loaded, the concrete beam is forced initially into compression (this precompression is termed the prestress) so as to neutralize the subsequent tensile forces due to load.

Steel in Beam

The best method to prestress a concrete beam is to pass steel through the concrete, anchor one end, stretch the other end, and then clamp the stretched wire at the other end of the beam. The steel, having elongated under stress, will attempt to regain its former length once the stress is removed, but being fixed at both ends it cannot do so without pulling on its anchors and compressing the concete. The steel in the prestressed concrete beam serves only as a device to impact the initial compression, after which the concrete beam resists all tensile forces due to loading. This is in contrast to the steel in reinforced concrete which resists the tensile forces due to loading.

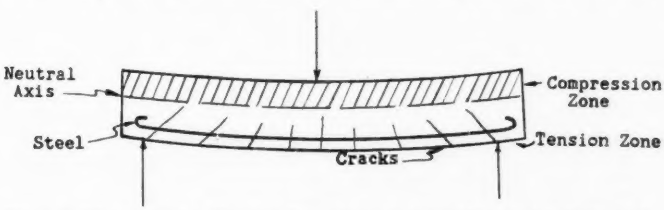


Figure 1—Effect of Load on Concrete Beam. Concrete is considered to be effective only in resisting compressive stresses.

—Courtesy The Author

While prestressed concrete may seem novel today, its principle was recognized as far back as 1880, when the German, Doehring, took out the first patent for a prestessed mortar slab. But he, as well as subsequent experimenters, were doomed to watch their prestressed sections, initially capable of resisting loadings, fail after a brief lapse of time. This loss in prestress was not adequately explained until 1927 when the eminent French Engineer, Eugene Freyssinet related the loss of prestress to shrinkage and plastic flow in the concrete.

After a lapse of time concrete will lose much of its water of cementation and begin to shrink. Also if concrete is compressed it will continue to deform away from the load, reaching a maximum deformation after a few years. This latter phenomenon is termed plastic flow. These reductions in length of a prestressed concrete beam will draw the anchors together and release part, if not all of the initial tensile force on the steel and consequently remove an equivalent part of the precompression on the beam. Freyssinet realized that if he wanted to maintain prestress in his beams he would have to stress and elongate his steel an amount equivalent to his desired precompression plus estimated losses due to shrinkage and plastic flow, generally estimated at about 40,000 psi. For this purpose, obviously, he could no longer employ ordinarily used mild steel with a yield point of only 45,000 psi, and so he began to use cold drawn steel wire with yield points around 200,000 psi. He could then safely stress the wire up to 180,000 psi, satisfy shrinkage and plastic flow losses, and still have enough tension to provide for high precompressions which would in turn permit very high tensile loadings. To be able to withstand the high initial precompression and to reduce beam dimensions, he developed very strong concretes by rigorous curing and by using low water-cement ratios.

Pro and Con

It might be argued that using better grade steel and concrete in reinforced concrete to strengthen the beam and to decrease the quan-

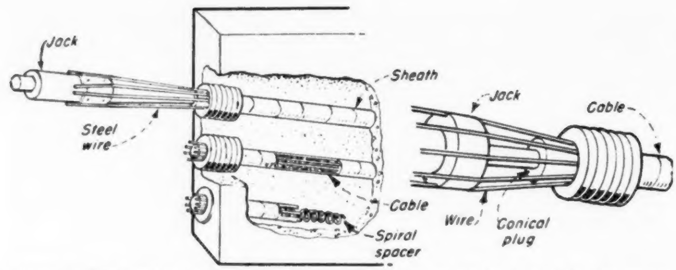


Figure 2—The Double-Acting Jack of Freyssinet (From article by L. Coff in Engineering News Record.)

tity of materials required for a beam might preclude the need for prestressed concrete. This is not so. Increasing the design strengths has the effect of raising the neutral axis which reduces the amount of concrete actually working to resist compression. This increase in the amount of useless concrete plus the extra cost required to produce higher strength concrete is sufficient to offset the saving in reduced dimensions obtainable by using higher strength concrete. The use of higher strength steel while reducing the amount of steel required to resist the tensile stresses introduces another difficulty. The greater tensile stresses in each individual bar produce greater elongations, in turn causing larger cracks in the concrete. For example if steel with three times the strength of ordinary reinforcing bars is used, one-third of the steel will be needed for the tension stresses. But the elongation and the size of the cracks will increase threefold and the exposed steel will be much more susceptible to the destructive action of corrosion.

In prestressed concrete, all of the concrete works. Cracks do not occur, and better grade steels and concretes can be used with marked savings in material quantities.

Prestress Systems

For a decade many successful prestressed concrete structures were built, chiefly circular tanks; but it was not until the eve of the war that prestressed concrete girder construction came into its own.

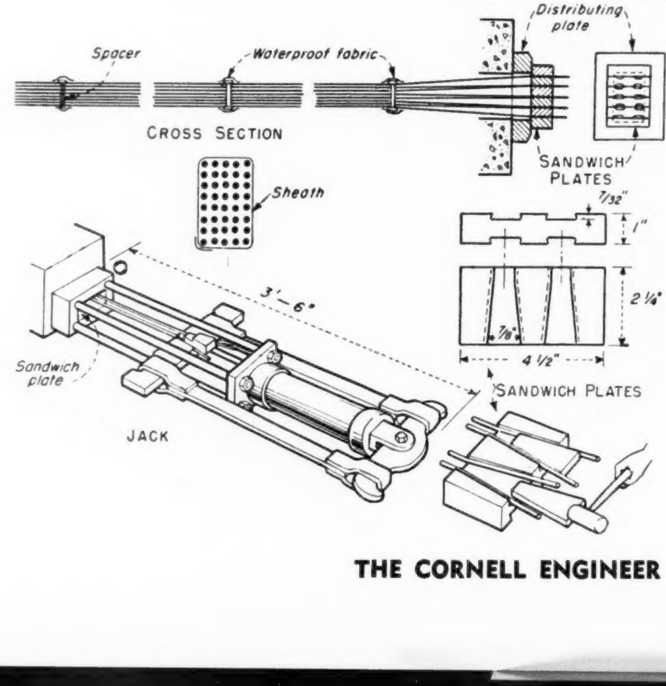
In 1939, Freyssinet developed his present system of prestressing wires for concrete girders. One action of his hydraulic jack (see Figure 2) stresses 8 to 12 wires, grouped in a circle, to a desired tension and then another action of his jack rams a concrete conical plug into a hole left at the end of the concrete beam. In that manner his wires are quickly secured.

Magnel developed a more dependable and compact anchorage system which provides for more complete security against slipping of the highly stretched wire. The Magnel jack (see Figure 3) stresses but two wires at a time to insure equal tension in each wire. The wires rest on machined steel "sandwich" plates and as each of the two faces of the sandwich plates can hold four wires, there are as many sandwich plates placed over each other as there are multiples of eight wires in the cable. A machined steel wedge is then driven between the wires to secure them. The sandwich plates are made to bear on distributing plates which effectively distribute the precompression to the concrete beam. The Magnel system has been widely used in Belgium and the Netherlands and is being used for the Walnut Lane Bridge in Philadelphia. Preload Enterprises, Inc., of New York City, designed the bridge in collaboration with engineers of the City of Philadelphia, following principles developed by Enterprises Blaton-Aubert, of Brussels, with whom Professor Magnel is associated and under whose patents Preload Corp. is the exclusive licensee in the United States.

Hollow Cores Used

In the Philadelphia girder, each of three steel cables was passed through hollow cores the length of the girder and formed by inserting rubber tubing during pouring operations and removed after hardening. A longitudinal cross-section of the girder in Figure 4 shows a parabolic curve to the cables. The parabola has been found to be the best curve for the steel in a straight, simply supported prestressed concrete girder. The parabola causes the steel at the center of the beam to be at a maximum eccentricity from the neutral axis (which in prestressed concrete girders corresponds to the longitudinal gravity axis) while the ends are secured so that the resulting eccentricity is zero. Maximum eccentricity at the center of the beam creates as great

Figure 3—Magnel's Anchorage System
—Courtesy Engineering News Record



a compressive force in the bottom fibers as possible in order to resist the later flexural tension due to loads. While it is true that the top of the girder may receive some small tension due to the eccentric prestressing, this tension will later be neutralized by compressive stresses due to loading.

Non-constant Stress

These flexural stresses, both tension and compression, due to loading are not constant over the length of the simply supported beam. They are a maximum halfway between supports but decrease to zero at the supports. If constant eccentricity is maintained the length of the beam, there will result permanent tensile stresses at the top fibers at the beam ends since there are no compressive stresses due to loads there, to neutralize the tension due to prestress. Consequently the eccentricity of the steel is made zero at beam ends.

A parabolic curve for the wires serves to further reduce the possibility of diagonal tension cracks in the concrete. The diagonal cracks are caused by a tension stress which is the resultant of horizontal tensile stresses and vertical shear. Horizontal precompression eliminates horizontal tension in the beam as shown before, but as a parabola has a downward curvature, the stress on the steel will produce a downward vertical component which reduces the upward vertical shear stresses due to the reactions.

Prestress Steel

In contrast to the Freyssinet and Magnel systems of stressing the wire through hollow cores left in the hardened concrete, Hoyer in Germany stressed his steel wires in the forms before pouring the concrete. Then when the concrete had hardened he cut the wires from their stressing devices and as the wires attempted to regain their original length, they precompressed the concrete. But as Hoyer used no end anchorage devices such as the Freyssinet plug or Magnel sandwich plate and wedge, he had to count only on bond or frictional resistance between steel and concrete to prevent the ends of the wires from regaining their original length by slipping in the concrete and causing the loss of the prestress. Since bond increases with increasing surface area, the Hoyer system requires many fine wires, 5/64" diameter with their greater ratio of perimeter to cross sectional area in contract to the 1/4" diameter used by Feyssinet and Magnel.

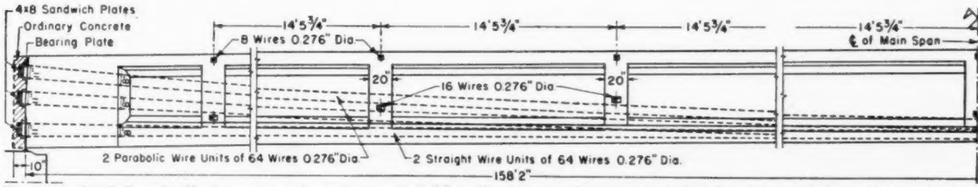
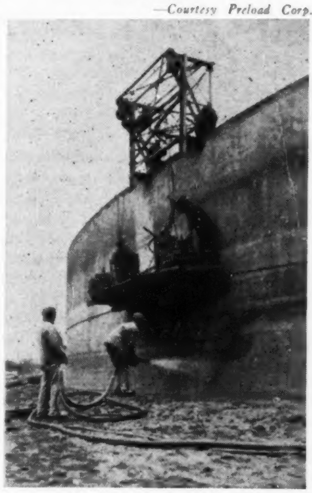


Figure 4—Half Longitudinal cross section of a typical Magnel prestressed concrete girder showing parabolic path to cables.
—Courtesy Civil Enigineering

The Freyssinet, Magnel and Hoyer systems have one thing in common. They are mechanical systems where the wire is stressed by a mechanical device such as a jack. However, any method which can put precompression in concrete by initially elongating the steel is legitimate. Thus K. Billner in the United States elongates his steel by inducing an electrical current through the unbonded steel and then clamping the ends. Precompression begins as soon as the current is shut off and the steel attempts to regain its original length. Mr. Loessier in France has experimented with expanding concretes which will stress the encased steel and in turn precompress the concrete. The electrical and Loessier methods do not however yet yield the high prestresses that the mechanical methods can.

Typical view of the Preload wire winding machine wrapping and stressing wire about tank.
—Courtesy Preload Corp.



The Future of Prestressed Concrete

Today, it appears that the applications of prestressed concrete are truly unlimited. Tanks, pipes, bridges, including a continuous bridge in Belgium, and roof girders for factories (see photo) and hangars have already been built by the use of prestressed concrete. In Sweden the Betrongindustri applying the Hoyer system builds roof girders, piles and posts on an assembly line in its factories. Precast floor slabs, telephone and telegraph poles, and railroad ties are commonly found in England and France.

In European and South American countries where materials, especially steel, are expensive, but labor inexpensive, prestressed concrete offers the ideal solution for the building of inexpensive, strong and crack-proof concrete structures. In the United States, where the reverse is true, the application of prestressed concrete may proceed more slowly but as the erection and prestressing techniques are improved and become familiar to contractors, and in cases where prefabrication has a greater role, the use of prestressed concrete will become more established. Even today in the United States, prestressed concrete can compete favorably with steel and conventional reinforced concrete on many types of structures.

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"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University its graduates and former students and to establish a closer relationship between the college and the alumni."

President's Message

There is in instrument flying an expression known as "bracketing the beam." The beam is, of course, the invisible radio track which guides the airplane to its destination and landing. The approach to this path is usually made from one side or the other and the bracketing process consists in a series of heading corrections, crossing and re-crossing the path, getting closer and closer to the final heading straight down the beam. This is a technique which we can and should use most effectively to produce the answers which are required of us as Engineers. The principle is just as important to people in other walks of life, but at the moment, I am interested only in Engineers and Engineering students, so I will try to point up by example just how this procedure can help you and lead to the invaluable development of judgment.

An Engineer is never supposed to say "I don't know!," in answer to a proper technical question in his field. He can sometimes get away with a statement that he will find out and be back in a short time with an answer. His best response, however, is something like "To the best of my present knowledge and judgment, this is my answer"—which he can modify by adding "I will find out more about it and let you know, if wanted." The important question is how do you produce that prompt and reasonably accurate answer which very frequently suffices to dispose of the question, and how do you develop increasing facility to provide such answers without strenuous mental effort and turmoil?

Let me give an example of what has actually happened in my office with one of my Engineers. We proposed to erect a temporary frame terminal building of typical design at one of our stations. Before approving the project, however, I asked the Engineer, "How much will it cost and how long will it take?" He came back promptly with the answer—which is no answer at all—"I haven't the least idea and I really can't tell until we have worked out the details of interior arrangement and equipment." So I directed my next question—"Will it cost $100,000?" and he answered, "Oh! Not that much." Then I said: "Will it cost $100?" and he replied, "Obviously a great deal more than that." Then I inquired, "Will it cost $50,000?" and he said, "Oh, no, not as much as that." Then I said, "Will it cost $5,000?" to which he answered, "More than that, I am sure." Subsequently, we determined that it would not cost more than $30,000, and it could not possibly cost less than $20,000, and it looked as though $25,000 would be a very fair figure. The same bracketing was applied to the time for completion—starting with a negative doubt and coming out with the answer that it would probably take about three months.

So, what started out to be an indicated failure of the Engineer to supply the requested information developed very simply into a firm judgment answer quite satisfactory for the purpose. And in this, as with all other good habits, practice makes perfect and "bracketing your guesses" will finally lead to the intelligent and rapid subconscious application of sound judgment. And don't ever forget that good judgment and its constant application distinguish the leaders of Engineering from those who are led.

William Littlewood

Seeing the Invisible— By Electron Microscope

By HARRY E. PETSCHEK, EP '52

THE recent development of the electron microscope has made possible the viewing of particles in the range between eight and a thousand Angstroms. Particles of this size cannot be seen with a light microscope regardless of the degree of refinement. The limit of the resolving power of the ordinary microscope has been determined as roughly one half the wave length of light in the medium in which the object is suspended, divided by the aperture of the microscope. For ultra-violet light and the proper suspension medium of the object this limit can be reduced only slightly below a thousand Angstroms.

First proof of the molecular arrangement in a true crystal of plant virus protein is revealed in this micrograph taken by Dr. Ralph Wyckoff of the National Institute of Health, Bethesda, Md. with the aid of an RCA electron microscope. At a magnification of 65,000 times, single crystals of the necrosis virus reveal their molecular arrangement. Individual spheres are the individual molecules, each approximately 100 Angstroms in diameter.

—*Courtesy R.C.A.*

Limitations of Light

This limitation on the light microscopes was discovered about seventy years ago by Ernst Abbé. From then until the discovery of the wave nature of X-rays in 1912, little hope was held out for the possibility of ever passing this limit. X-rays have a short wavelength, approximately one Angstrom. This would reduce the limit of the resolving power considerably, if a satisfactory refracting medium could be found. The index of refraction for X-rays in almost all mediums is so close to unity that it is impossible to construct an X-ray lens. Some work has been done in X-ray optics by means of reflection, but the perfection that has been reached by the electron microscope has not and probably cannot be reached with X-rays.

The first clue that led to the development of the electron microscope was de Broglie's Theorem in 1924 explaining the wave nature of an electron beam. This was closely followed in 1926 by H. Busch's important discovery that axially symmetric magnetic and electric fields act in the same way on a stream of electrons as lenses act on light rays. The first electron microscope using a magnetic lens was reported by Knoll and Ruska in 1932. At first it was not as good as the existing light microscopes. After four years of research the resolving power of ordinary microscopes was reached. Since that time the resolving power of the best light

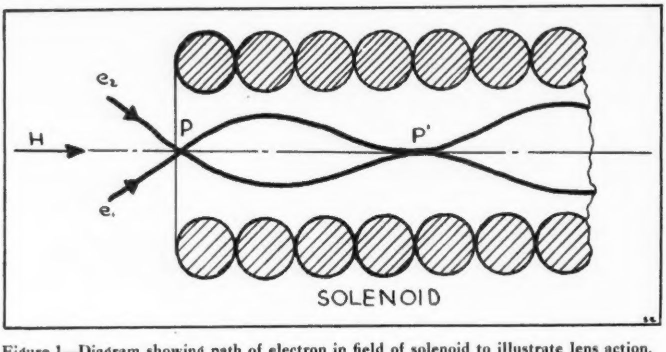


Figure 1—Diagram showing path of electron in field of solenoid to illustrate lens action. —*Stan Cohen*

instruments has been exceeded by a factor of one hundred with the electron microscope. Because the aperture of an electron microscope has to be very small in order to avoid serious spherical aberrations, the resolving power is not as great as might be expected from the fact that the wavelength of an electron is only 0.05 Angstroms, one one-hundred thousandth of the wave length of ordinary light.

Electron Lenses

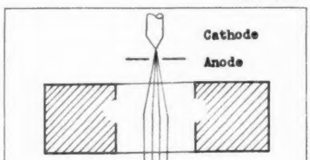
Electron lenses are essentially electrostatic, electromagnetic, or permanent magnetic fields. The simplest type is the field of a solenoid. The lens properties of a solenoid may be understood when considering the path of an electron that enters the field of a solenoid at a point P in Fig. 1 and at an angle to the solenoid axis. The component of the velocity perpendicular to the axis will be accelerated in a direction perpendicular to its motion by the magnetic field. This acceleration will cause the electron to move in a circle. When this circular motion is coupled with the unaffected motion parallel to the axis the result is a helix. This helix will be wound around an imaginary cylinder tangent to a line through P and parallel to the solenoid axis. Thus, all electrons leaving the point P with the same magnitude will pass through the point P′ after a whole number of complete helices. The point P′ will then be a focal point of the system.

The electrostatic and magnetic lenses follow very closely the laws developed for glass lenses. The equation:

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

where f is the focal length, and u and v are the object and image distances, holds true; but just as in light optics it is exact only for the single ray passing along the axis of the lens. The magnification of the image, as in light optics, is equal to v/u.

Figure 2—Schematic diagram of electron microscope. —*Stan Cohen*



Focussing the Lenses

From the discussion of the lens properties of a solenoid it may be seen that the length of the helices described depends on the strength of the magnetic field. As the field strength is increased the diameter of the helix is decreased. Since the magnitude of the velocity is unchanged, the length of the helix and, therefore, the focal length of the lens is decreased. Focussing of a magnetic lens is therefore easily achieved by varying the current in the solenoid winding. Thus, while the electromagnetic lens is adjusted by varying the current, the electrostatic and permanent magnet lenses must still be focussed by varying the object to objective lens distance, as is done in light microscopes.

The electromagnetic lens has the disadvantage that the focal length is a function of the accelerating potential of the electrons. In order to maintain a high degree of accuracy in the focal length, the accelerating potential may not vary more than 0.01%. The focal length of an electrostatic lens, on the other hand, is a function of the ratio of the accelerating potential of the electrons to the potential of the lens. Thus, if these potentials are supplied from a common source so that their ratio remains constant, the focal length of the lens will not be affected by slight variations in the source potential.

Lens Aberrations

Electron lenses are subject to the same aberrations which affect glass lenses. However, in glass lenses aberrations are compensated for by using sets of concave and convex lenses. This is impossible in the magnetic lens because the focal length is a function of the square of the magnetic intensity. Thus, for a negative lens, the magnetic intensity would have to be an imaginary number. The case of the electrostatic lens is somewhat analogous, in that the focal length is a function of the square of the potential ratio.

Microscope Mechanism

A schematic diagram of the construction of an electron microscope,

produced by RCA, is shown in Fig. 2. The ray diagram is analogous to the ray diagram for an ordinary light microscope. The electron source is usually a hot tungsten filament maintained at a constant potential. The beam of electrons from the filament is accelerated to a high velocity by a grid and then passes through a hole in the anode. This beam is then comparable to light rays that illuminate an object

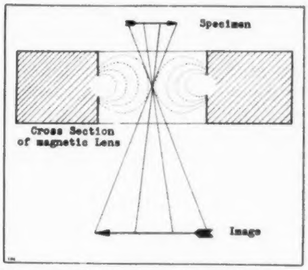


Figure 3—Field of toroidal windings used as lenses in RCA electron microscope.
—Stan Cohen

in an ordinary microscope, and are then focussed to form an image. After passing through the anode, the electrons are bent into converging rays by the condenser lens, a torodial winding. A diagram of the field caused by such a lens is shown in Fig. 3. These converging rays pass through the object, where they are affected in varying degrees depending on the composition of the object. After the electrons pass through the object they are brought to a focus by the objective lens and form an enlarged primary image. A part of this image is then further enlarged by the projective lens to form the final image. The electron beam that forms the final image is itself not visible. The image is made visible by placing a fluorescent screen in the plane where the image is formed. Electron micrographs are made by substituting a photographic plate for the fluorescent screen. In order to avoid interaction between the beam of electrons and gas molecules and ions, the entire path of the beam, from the emitter to the final image, must be in a highly evacuated chamber.

Interaction of Beam and Specimen

An important part of electron microscopy is the interaction of the beam of electrons and the object specimen. Elastic collisions occur between the electrons in the beam and the positive nuclei of the atoms of the specimen. If the angle through which these collisions cause the electrons to deviate is sufficiently large, the electron will not pass through the aperture. This decrease in the number of electrons that reach the image will cause a dark spot in the image. The electrons that are deviated through smaller angles and pass through the aperture would, with an ideal lens, be brought to focus in the image plane. However, since all lenses are subject to spherical aberrations, some of these electrons are not brought to focus in the image plane. Thus, again decreasing the intensity of light seen at that point of the image. A decrease in intensity is also caused by the inelastic collisions of the beam electrons with the field of the atomic electrons in the specimen. These collisions reduce the velocity of the electrons in the beam, which also causes improper focusing.

Light rays incident on a piece of matter may be absorbed, refracted, or scattered in passing through. In light microscopy all three of these effects are used in obtaining contrast in the image. Various methods of accentuating these effects, such as staining, have been developed in order to increase the contrast shown in the image. Electron microscopy is handicapped in this respect because the only effect that matter has on an electron beam is scattering. Obtaining sufficient contrast in the image using the scattering effect alone is one of the problems of electron microscopy.

Shadow Casting

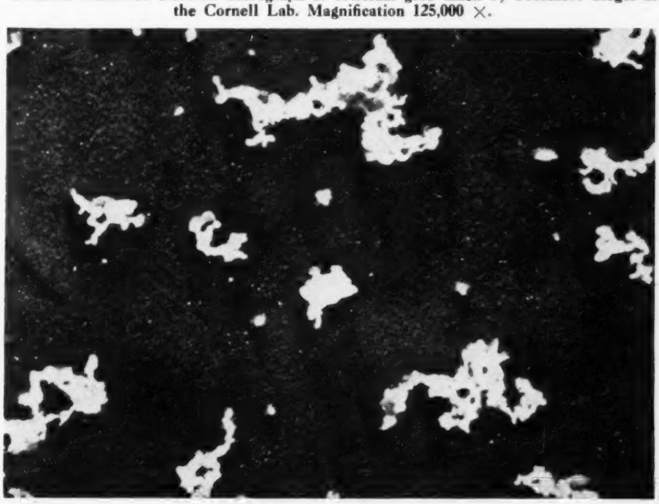
If a thin layer of metal is used to coat the surface of a specimen, the scattering effect will be increased. This technique, known as shadow casting, was used by Professor Benjamin Siegel, in charge of the Electron Microscope Laboratory here at Cornell, in obtaining the micrograph shown below. Uranium was evaporated onto the specimen of colloidal gold at an oblique angle. The surfaces of the specimen that were completely exposed to the rays of uranium received the heaviest deposit while other surfaces that were shadowed by the specimen received lighter deposits. Scattering of the electron beam when the coated specimen is viewed with the electron microscope depends on the thickness of the coating. This creates an image whose contrast is very much like the variation in the intensity of sunlight on a landscape.

Mounting of Specimens

Another problem incurred in electron micçoscopy is the mounting of the specimen. The glass slides that are usually used in light micro-

(Concluded on page 34)

Uranium shadowed electron micrograph of colloidal gold taken by Professor Siegel at the Cornell Lab. Magnification 125,000 ×.



Profile

Perhaps one of the most fabulous men of science in his generation is Peter J. W. Debye, chairman of the Chemistry Department at Cornell. With the increasing trend for specialization, Debye is one of the few remaining to whom the term "scientist" may be applied without reserve. Among the widely scattered fields in which he has taken a major part are electricity, physics, and chemistry. His fame is in no small part due to the fact that he has been equally productive in so many different of the sciences.

Generally considered to be a physical chemist, Debye's basic education, oddly enough, was in

Dr. Peter J. W. Debye

electrical engineering. Born March 24, 1884, in Maastricht, Netherlands, he attended elementary school there. After finishing his primary education, he went for four years to the Technische Hochschule, graduating in 1905 with a degree in electrical engineering.

Debye lost little time in gaining momentum. He soon became interested in chemistry and physics as a sideline. After graduating from Aachen, he became assistant to a professor in theoretical physics at the University of Munich, where he was able to conduct experiments and continue his study.

Not long after receiving his Ph.D. in 1908, he was granted a full professorship at the University of Zurich, filling the position of none other than Albert Einstein. It was not long until he moved on to become professor of theoretical physics at the University of Utrecht in the Netherlands.

This was not the end of Debye's travels. He accepted a position at the University of Goettingen in Germany, taking over a laboratory and continuing his research. In 1920 he was made director of a physics laboratory in Zurich. He also spent some time at the University of Leipzig. In 1936 he accepted a professorship at the University of Berlin.

With the coming of war, the Nazis made it difficult for Debye, a Dutch citizen, to continue his work. Not being able to accept their proposals, he accepted instead a position here at Cornell in 1940 and has been here ever since.

Debye is known, not because of the many positions he has held, but rather because of the tremendous amount of work he has done in so many of the fields of science. His contributions have been many and varied for which he has received international recognition including the coveted Nobel prize. In the course of his research Debye has developed equations for the heat capacities of molecules at low temperatures, and a theory for the scattering of light by polymers to determine the size and shape of molecules. He is famous for his work on X-ray analysis for the study of molecular structures. He has developed a method for determination of crystal structure and has done work in the field of magnetic cooling. His efforts in the study of molecular structure were rewarded with the Nobel prize in 1936. He has won numerous other honors, the latest of which is the Gibbs Medal of the American Chemical Society, and is a member of scientific societies from here to Amsterdam.

Debye has little time for plying a hobby, but is admittedly fond of fishing. Fortunately for Cornell's Chemistry students, he is in favor of giving them time that is free from study, for only in this way does he believe that the ability to think can be developed.

The Editor's COLUMN

Wanted—More Courses

Of the many publicity releases which slip into our office daily via the postman, most find their way almost immediately into what we term our circular file—that is, the wastebasket. It was indeed a contrast, then, to recently discover a release which not only attracted our interest, but which also is believed worthy of editorial comment.

The release in question, a product of a midwestern machine tool company, announced the availability by the company of a course, covering new advances in a particular line of tools, to schools and colleges. Principally a correspondence course in nature, it is designed so as to supply teaching materials, student work-sheets, instructors' kits, and home-study material, all without charge. Provision is made to allow this course to act as a supplement to present courses in schools.

As to the reason for the development of the course, the company states that it feels it necessary to acquaint students of new advances and techniques in the tool industry, since it is well known that school facilities are often insufficient to educate students in the *latest* in scientific and technological developments.

The sincerity of this manufacturer in his purpose may be doubted, since it appears that the company's techniques and products have been overemphasized in the outline of the course. In principle, however, the company has developed a fine idea into a program more concrete than any other such method ever brought to our attention. The foundation of industry lies in the educational system; surely it is the responsibility of industry to grant more than mere financial assistance to its welfare. Crude as the method may be, this company has done just that in forming this course, and we hope such an idea will be seriously considered by other representatives of industry.

Alumni News

Lesley Ashburner, CE '06, recently retired after having been a consulting structural engineer for the US Government for the last ten years. He worked on the design of the Pentagon building for more than a year, as well as on other large government buildings.

George F. Hewitt, ME '10, writes: "Having resigned from my job in order to spend the summer in England and Scotland, I am now looking for another connection. Recently, I became critical of certain phases of local government; as a result, I have been appointed to the Montclair, N. J., development board. Hope I have learned a lesson."

Samuel A. Graham, CE '11, is sales manager for Cameron Lumber Co., Inc., Newburgh, N. Y., wholesale distributors of lumber, millwork, and other building materials.

A. Griffin Ashcroft, ME '21, director of research and development of Alexander Smith & Sons Carpet Co., Yonkers, N. Y., received October 19 one of the first two awards given by the American Society of Testing Materials for outstanding scientific contributions to the wool industry. The honor was bestowed on him as "a mark of deep appreciation for his tireless efforts as chairman of the wool subcommittee (of the Society) for the past ten years" during which time "he recognized the need for standardization and test methods, and pioneered the development of statistical techniques and quality control."

A. Griffin Ashcroft

S. Lewis Elmer, Jr., ME '31, has been with Sverdrup & Parcel, consulting engineers, Syndicate Trust Building, St. Louis 1, Mo., since the first of the year.

Alvan B. Worth, CE '33, of Poultney, Vt., is senior engineer for Barker & Wheeler, engineers in Albany and New York City. He resigned as engineering specialist in the U.S. Department of Agriculture Soil Conservation Service in May, 1948, to take the position.

Jean F. Mitchell, ME '35, has resigned as consulting engineer for the Chamberlain Corp., Waterloo, Iowa, to become general sales manager for Granberg Corp., Oakland, Calif., manufacturers of pumps and meters for the petroleum industry.

John A. Franz, CE '35, project engineer for California Texas Co., was in Cartegena, Spain. He left for Spain on August 5 and returned in the end of December.

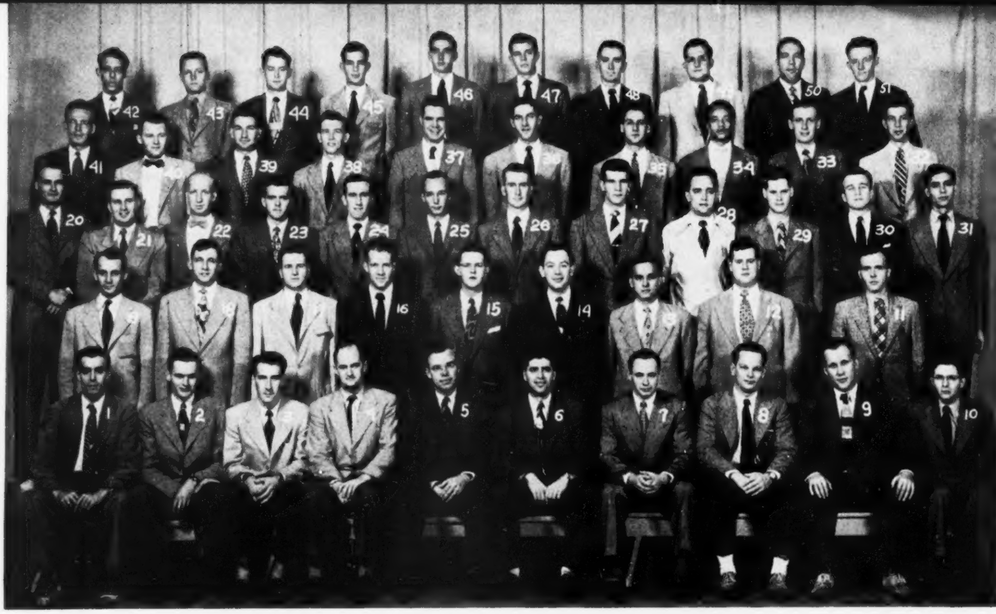
Robert G. Lyon, ME '35, was recently appointed director of product education on passenger cars and trucks for Ross Roy, Inc., Detroit advertising agency. Lyon joined Ross Roy, Inc., in 1948 after serving as chief engineer of the Visco-Meter Corporation of Buffalo, N. Y. He is a member of the Engineering Society of Detroit, the Society of Automotive Engineers, and the Cornell Engineering Society. He is also chairman of the Detroit Chapter, Auto Maniacs of America.

Robert G. Lyon

Robert W. Persons, B.E.E. '48, is in designing and consulting engineering with Ebasco Services, Inc., New York City, lives at 213-05 Twenty-ninth Avenue, Bayside, N.J.

James J. Mills, B.E.E. '48, is a contract field engineer for the Philco Corp., working on a contract with the Navy Bureau of Ships and stationed at present at the San Francisco, Cal., Naval Shipyard. His home is at 4644 Old York Road, Philadelphia, Pa.

Warren H. Heimer, B.M.E. '49, completed forty-five days of active duty with the US Air Force as second lieutenant at Otis Air Force Base, Mass., August 31. Back on Reserve status again, he started work as a test engineer at General Electric Co., in Philadelphia, Pa., October 24. His address is 503 N. Norwood Street, Arlington, Va.



SCHOOL OF MECHANICAL ENGINEERING

1. Logdon, C.
2. Jacobs, E. S.
3. Jennings, N. R.
4. Heller, R. H.
5. Loberg, H. J. (Prof.)
6. Savitz, R. S.
7. Hines, J. W.
8. Benson, M. M.
9. Hoerle, F. O.
10. Hirsch, A. R.
11. Dryden, W. A.
12. Ohaus, W. G.
13. Toda, N. F.
14. Roberts, D. K.
15. Shepherd, R. F.
16. Allen, R. C.
17. McKinney, J. L.
18. Anderson, R. S.
19. Taylor, G. M.
20. Reineman. H. H., Jr.
21. Bogert. R. S.
22. Edwardsen, M. L.
23. Alley, A. R.
24. Shelley, F. J.
25. Rasmussen, K. E.
26. Conniff, R. P.
27. Brookfield, M. B.
28. Gummer, R. E.
29. Young, R. A.
30. Kennedy, D. W.
31. Logdon, G.
32. Smith, E. H., Jr.
33. Kingston, W. J.
34. Robinson, S. M.
35. Ullman, J. J.
36. Hartley, H. S.
37. Harris, H. L., Jr.
38. McGuff, T. J.
39. Pearlman, S. R.
40. Wood, C. C., Jr.
41. Driscoll, F. E.
42. Elow, D. I.
43. Stone, W. S.
44. Gubb, W. E.
45. Friedrich, W. H.
46. Rumsey, D. G.
47. Brown, T. H.
48. O'Brien, E., Jr.
49. Hoepfner, M. G.
50. Somers, D. V.
51. Allingham, W. F.

Class of February, 1950

SCHOOL OF ELECTRICAL ENGINEERING

1. Kotula, M. S.
2. de Leon, L.
3. Godwin, C. J., Jr.
4. Goodman, J. P.
5. Morrison, R. F.
6. Northrop, B. K. (Prof.)
7. Dawson, E. C.
8. Gerb, B.
9. McCann, R. C.
10. Watson, R. G.
11. Messner, W. S.
12. Chen, K.
13. Chu, J. H.
14. Barton, G. H.
15. Ross, I.
16. Loring, B. L.
17. Knapp, S. S.
18. Kline, H. C.
19. Blum, H.
20. Lebid, J.
21. Reeder, C. E.
22. Bryon, D. S.
23. Guilbert, R. T., Jr.
24. Parsons, D. B.
25. Flood, W. A., Jr.
26. Tenney, G. G.
27. Bettcher, A. A.
28. Moore, R. C.
29. Cooke, R. S.
30. Smith, H. E.
31. Sommers, T. W.
32. Moonan, P. J.
33. Himelfarb, F.
34. Cooper, E. S.
35. Pearson, W. F.
36. Barnes, J. E., Jr.
37. Gordon, R. L.
38. Johnson, A. D.
39. Benson, R. V.
40. Rissler, R. L., Jr.
41. White, L. E.
42. McCulloh, W. L.
43. Przybyl, R. P.
44. Lane, J. H.

College News and Views

By JOHN H. GAY, EP '51

New Voltage Laboratory

In late winter of 1948, Cornell's High Voltage Laboratory burned to the ground with the loss of more than a million dollars worth of equipment and facilities. Heavily endowed by industry to pursue research in fundamental and applied topics, the laboratory was one of the best of its kind in the world. The spectacular fire endangered the settlements at Vetsburg, several nearby structures and spectators from every corner of Ithaca, including some local firemen.

Happily, there has been intense, carefully directed activity devoted to the reestablishment of the laboratory. Today, the visible aftereffects of the blaze have been completely removed. The grotesque warped structural girders and mutilated shreds of machinery have been carted away. Some of the larger pieces, which by virtue of their massive size and sturdy components were only partially damaged, will be used again in new functions. An example of this is that the cases for the 23-kilovolt transformers are now to be used for tankage.

A mobile crane is shown being used to unload froma flat car one of the 20-ton transformers recently received by the high voltage laboratory as part of their rebuilding program.

To replace some of the lost equipment, aggressive steps were taken to obtain items through the war surplus program. Welding, heat-treating, radio, radar, and power-plant equipment that could be adapted to high-voltage studies were acquired this way. A five-ton crane car acquired from war surplus has been particularly useful, not only in rebuilding the high voltage lab but in general applications around campus.

On the Mitchell Street site, a 40 by 100 feet aluminum storage building has been erected, which will eventually be integrated with the high voltage lab operations. The construction of this building was contemplated before the fire and was, of course, made imperative at that juncture. It now serves to hold material which will be directly applicable to the reconstruction of the lab.

The University has received from the General Electric Company two large transformers of particular interest. One transformer is a single-phase, 2300/15000-volt machine with multiple windings which will enable power to be obtained directly at 1000 kva for all voltage ratings between 2300 and 15000 volts, thus enabling heavy power circuits to be studied.

The other transformer, originally rated 500 kva, 50000 volts, will permit single-phase high-voltage operations at 60 cycles, supplying up to one ampere.

The University has purchased, in addition, a three-phase transformer capable of delivering 10000 amperes at voltages up to 280 volts. This machine is available for tests of the forces between conductors, and the heating and reactance of low impedance circuits under full load and high current conditions.

Many other gifts have been offered by those interested in the reconstruction of this project. Some of this material has been accepted and is either being held or is on loan to other divisions of the University which plan immediate use, while other material has been refused pending a clarification of the administration's wishes regarding scope and policy of reconstruction efforts.

* * *

The *Engineer* Congratulates:

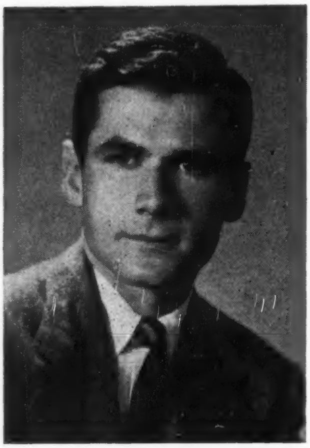
Frank Zurn—*for a job well done in three and a half years as an undergraduate ME and a leader in campus and community affairs. Frank is at present handling the jobs of business manager of the Cornellian and head cheerleader and has, in previous years, served as president of his class, backstroker on the swimming team (this phase of Frank's college activities came to an end in late 1947 when he put a little too much into one cheer at the Penn-Cornell basketball game and broke his wrist), member of the student council, freshman camp counselor and active Sigma Phi. Cornell's plethora of honorary societies has recognized his interests and, more, his accomplishments as an active Cornellian, resulting in his election to Atmos, Aquarius, Pi Delta Epsilon, Aleph Samach and Quill and Dagger. Graduation plans*

Frank

include working in the field of manufacture and sales of marine plumbing, drainage and industrial products.

* * *

John Coffin—*for playing a leading role in bringing Cornell two Ivy League championships in a row in soccer, for working with and co-captaining an ice hockey squad which, despite the handicap of the unfriendly lack of ice on Beebe Lake, has managed to maintain a schedule and a creditable record, and for a general contribution to Cornell. John, a Cornellian with a distinguished Cornell background including his father, Foster Coffin* '12, *director of Willard Straight Hall and his uncle, Donald Kerr* '12, *Counselor of Foreign Students, will receive his degree in civil engineering this spring after having entered as a physics major in the fall of* 1946. *Organizations and honoraries in which he is active include Red*



John

Key, Sphinx Head, Pyramid, CURW, the Shin Guard Club and Psi Upsilon. Graduate work in one of the natural sciences—for a long time his principle interests—seems to comprise John's thinking for the future.

* * *

Tom Elder—*for a recently completed term of office as president of Tau Beta Pi and for leadership shown in working with many others of Cornell's abundance of extracurricular organizations. A CE, who*

Tom

transferred after deciding that the electrical engineering course he entered in the fall of 1946 *was not to his liking, Tom (he would more likely respond t o"T.J.") has proved a valuable person to have in Lincoln Hall activities. Most of the work on Chi Epsilon's news letter (he, of course, belongs to both Chi Epsilon and Pyramid) was done by Tom during his term as editor. Other undergraduate interests include varsity soccer (two years on the squad), CURW and the Westminster Club. After graduation, Tom will be looking for a job which will temper his academic education with knowledge of the practical side of civil engineering.*

* * *

Ed Zajac— *for displaying a real interest and ability in the work involved in three years of undergraduate mechanical engineering and in the life of the university as a whole. As vice-president of Tau Beta Pi, secretary of the student chapter of ASME, and a member of Pi Tau Sigma, Ed has made a major contribution to promoting and coordinating student activities. In addition, his interest in music is evinced by his participaton in the Cornell Men's Glee Club (first tenor for the past four years) and in the chorus of "Shoot If You Must"—last spring's Octagon Club production. Ed's post-graduate plans are still indefinite, of course, but indications point to work in research and development on either heat-power or applied mechanics problems.*

Soils Research Program

Last spring vacation a group of Cornell CE's visited Puerto Rico to examine land forms under the auspices of a large soil research project commissioned by the U. S. Navy and headed by Professor Belcher. The objective of the project, still in progress as a major item in CE activity, is to develop a practical system of identifying soils and surface conditions through examination of aerial photographs.

The primary objective of this program is to develop a practical system of identifying soils and surface conditions through examination of aerial photographs. It has been shown that there are only a certain number of basic land forms in the world, and given soils and surface conditions are associated with each, no matter where in the world they are found. For instance, if a region contains a large number of sink holes, it can be concluded that the underlying rock is soluble limestone. The color of the soil and the vegetation growing on it are further indications of soil types.

Useful applications of such a system are obvious. By examining an aerial photo construction difficulties may be foreseen and estimated. The amount of trees to be cleared or the location of sources for construction material may be determined quite accurately. Buried stream channels, swamp areas, etc., may be located without setting foot

(Continued on page 28)

Ed

Techni-Briefs

Putty Protects Instruments

Bouncing putty, now widely used in golf balls and in devices which automatically level furniture, has been put to work in a new job. This time it is protecting the delicate instruments of V-2 rockets fired at White Sands. Wrapped in a half-inch coating of bouncing putty, motion picture cameras are hardly affected by the crash of the huge rocket after its hundred-mile plunge back to earth.

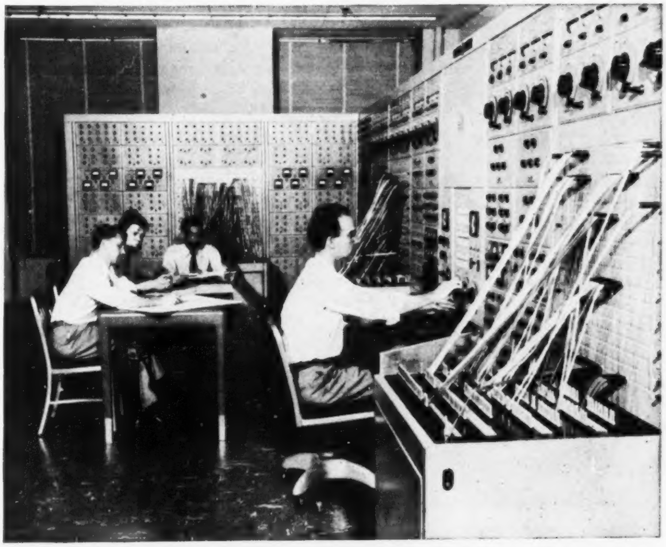
This silicone "putty" flows like ordinary soft glazing putty. When rolled into a ball, however, it has a lively bounce.

A-C Network Analyzer

A machine which can duplicate in miniature hundreds of miles of transmission lines in vast electric power networks, and solve in minutes network problems ordinarily requiring weeks to solve, has been developed by engineers of the General Electric Company. Called the "a-c network analyzer," the instrument includes miles of wire, hundreds of controls, sensitive measuring devices, and four plug-and-jack boards resembling those used by telephone operators.

A power network can be simulated on the analyzer by plugging lines into the plug-and-jack boards to form small scale versions of the real thing. Small generators, representing power stations, send current through the simulated network, and engineers can study the network's behavior at any point under a variety of conditions, such as additions of new lines, breaks in lines, and changes in the sources of power.

The network analyzer can also be used to solve many other scientific problems capable of expression in electric equivalents, such as the study of vibration in machinery, or the flow of air over an airplane wing.



A General Electric developed A-C network analyzer which is capable of solving in a short time very complex network problems by simulating them in miniature.

Similar instruments will be used by the Bureau of Reclamation in Denver, Colorado, and the India Institute of Science, in Bangalore, India, to design power systems.

High Speed Tempering

A tempering process which heats a metal surface from room temperature to a bright red, 1600 degrees Fahrenheit and cools it again to room temperature, all within five seconds, is now being used at the Switchgear Divisions of the General Electric Company in Philadelphia, Pa.

Developed for the tempering of small parts, the process uses an electromagnet which holds the part to be tempered within the field of a powerful electronic heater.

As soon as the part has been heated to the proper temperature, an automatic timing switch shuts off the electronic heater. At the same instant the current is removed from the electro-magnet and the part drops into a cooling bath of oil.

The process is being used to harden the toothed surfaces of small ratchet wheels for automatic circuit reclosers. An efficient tempering process is necessary since these parts must be able to withstand heavy impacts.

New Ductile Cast Iron

Industry now has available to it a new cast iron which, unlike ordinary cast iron, is not brittle, but can be bent or twisted. This astounding new material can be made readily and economically and can be used in a myriad of applications, thus affording countless economies

throughout the industrial world. The novel product, popularly known as ductile cast iron, has several times greater strength than ordinary cast iron with greatly increased ductility and shock-resistance.

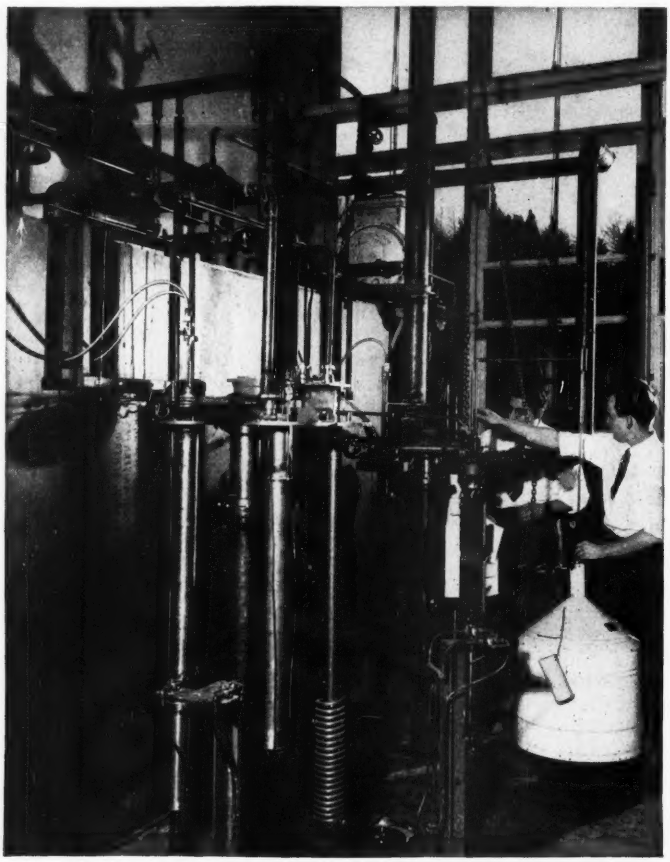
This new ductile cast iron combines processing advantages of cast iron, such as fluidity, castability and machinability, with many of the product advantages of steel. The essential feature of the inventions is the introduction into, and retention by, the molten iron under treatment of a small, but effective, amount of magnesium. The presence of critical amounts of magnesium in the cast iron produces a new graphite structure which is in the form of spheroids or compacted particles. By the elimination of a substantial amount of the usual weakening flake graphite, the new magnesium-treated cast iron is given excellent engineering properties, particularly high tensile strength, elastic modulus, yield strength, toughness, and ductility. Under stress, it behaves elastically like steel rather than like cast iron, having a high elastic limit with a modulus of elasticity of about 25 million pounds per square inch.

All Weather Jet Engine

Development of the nation's first "all-weather" jet engine for military aircraft was announced by the General Electric Company. New engineering features added to the General Electric J-47 turbojet have made the engine an "all-weather" powerplant capable of operating successfully under icing conditions. Adequate anti-icing protection is provided by the effective use of internally heated hollow parts at the nose. Heated parts include inlet guide vanes, fairings, and forward frame struts. Hot air supplied to these parts from the engine's compressor prevents large accumulations of ice at the inlet which shut off air flow and might even break off and enter the engine to cause severe damage.

In addition, reductions in the use of scarce alloys, like tungsten and cobalt, has greatly improved the "producibility" of the jet engines without sacrificing efficiency of life of parts.

Research at temperatures near absolute zero may be carried on in this new low-temperature research laboratory recently opened by General Electric. Some of the anomalies involving super-conductivity and other phenomena are expected to be resolved through its use.



Nylon Bearing

Nylon bearings and other parts molded of nylon plastic are greatly prolonging the life of many types of textile bobbins, according to results observed in some of the country's largest textile mills.

The use of nylon in bobbins is one of the latest textile machine applications for the versatile plastic. Nylon bearings have already proven especially satisfactory for use in many textile operations, as they require little or no lubrication, thus virtually eliminating spoilage of yarn by oil.

A bobbin recently developed features not only nylon bearings, but also introduces the plastic in flange rims on the rounded, protruding bobbin ends. Nicks in the metal flange rims formerly used snagged the yarn in winding and twisting operations, while the nylon rims remain smooth despite rough treatment.

Low Temperature Neoprene

A new type of neoprene synthetic rubber which shows a marked improvement in resistance of crystallization at low temperatures has been developed by L. R. Mayo, of the Organic Chemicals Department of E. I. du Pont de Nemours and Company. Neoprene compositions resist oils, grease, chemicals, heat, and sunlight much better than those of natural rubber.

Crystallization results in stiffening at low temperatures which is undesirable in such products as oil

(*Concluded on page 26*)

Engineering *Book Reviews*

ROUTE SURVEYS. By Russell B. Skelton. 531-pp; McGraw-Hill Book Co., Inc., New York. 1949. $4.50.

The author of this text has performed an excellent service by combining the established methods of surveying with the most modern methods and applied them in the manner to which they would be used in the fields of highways and transportation. The engineering approach to the problems and economic factors influencing route location and selection is well illustrated with numerous examples.

One of the most significant features of the book is the discussion of the use of aerial surveys and other recent advancements made by state highway departments. The application of aerial surveys is stressed throughout the text and discussed in detail for reconnaissance of route locations.

The major portion of the book is devoted to highway and railroad curves and spirals. This information is presented in the same manner as previous texts on route surveying but is enhanced somewhat by the use of example problems. Numerous problems to be worked out by the student are presented by the author to bring out the important points of each chapter, thereby making the book more valuable as a text.

The standard tables for route surveys are included in the text, rather than as separate items, which also increases the overall value of the book.

As a summary, I believe the book has definite merits, especially in the presentation of recent advancements in the field. However, the major portion of the book is devoted to the standard practices as found in any other text on route surveying although the presentation here is quite good.

Raymond J. Hodge
Asst. Professor of
Civil Engineering

STRENGTH OF MATERIALS By J. P. Den Hartog. viii + 323 pp; McGraw-Hill Book Co., New York. 1949. $4.00.

The present book is intended as a companion volume to the author's "Mechanics" which was published earlier this year by the McGraw-Hill Book Company. Professor Den Hartog will be recalled as the author of the celebrated "Mechanical Vibrations" and his descriptive style of writing should make the present text very popular.

The material covered is intended as an introduction to strength of materials and is suitable for a one-semester course. However, since there will be many topics which cannot be adequately covered in this period, those which may safely be omitted during a first reading are marked with an asterisk. The order of presentation is orthodox and is sufficiently flexible to suit the individual tastes of most instructors.

A list of problems is appended to each article, these problems (350 in all) being given on the last pages of the book. The author follows the rather unusual procedure of giving answers to every problem; this may find disfavor with some. The problems are, on the whole, an admirable collection and exercises in algebraic substitution have been avoided.

Outstanding features which are not usually encountered in a first course include a discussion of the Mohr circle method for moments of inertia and strains, calculation of center of shear, photoelasticity and electrical strain gages. Instead of giving preference to the area-moment method for calculating beam deflections, the author stresses instead a method whereby the beam is analyzed as consisting of one or more cantilevers. In the reviewer's opinion, it is doubtful whether this will find wide appeal.

H. D. Conway
Professor of
Mechanics

PLAIN CONCRETE. By Edward E. Bauer. 3rd Ed. xiii + 441 pp. McGraw-Hill Book Co., Inc., New York. 1949. $5.00.

This well-known book is primarily a combination textbook and laboratory manual designed for an undergraduate college course in concrete. It should also be useful to practicing engineers as a reference for specifications, testing, and supervision of construction.

This edition differs from the second edition primarily by addition of information on air-entrainment and alkali-aggregate reaction, by revision of out-dated specifications, by addition of study questions, and by minor revision of part of the text.

Raw Materials Studied

The treatment starts with a study of the raw materials used to make concrete — cements, aggregates, admixtures, and water. Sources, processing, properties, and testing of these ingredients are discussed. An extensive treatment is given of the theories and application of proportioning. The factors affecting concrete strength—such as cement, age, mixing, temperature, moisture, curing, and calcium chloride—are discussed briefly. Extensive coverage is made of the manufacture of concrete. This includes handling raw materials, batching, mixing, placing, vibrating, finishing, and curing. Twenty pages are devoted to the all-important subject of durability, combined with workability and waterproofness. Field control, specifications, and sampling are handled briefly, partly by quoting specifications of the American Society for Testing Materials. A helpful chapter on testing intersperses the author's comments and notes among the standard procedures quoted therein. The next 84 pages contain instructions for performance of laboratory tests, mostly quoted from the American Society for Testing Materials. The author includes questions to be answered by the student, and illustrates data record forms. Seven laboratory projects are outlined in detail.

The coverage of the book is adequate, except on durability. It is

(*Concluded on page* 32)

Machine Tools

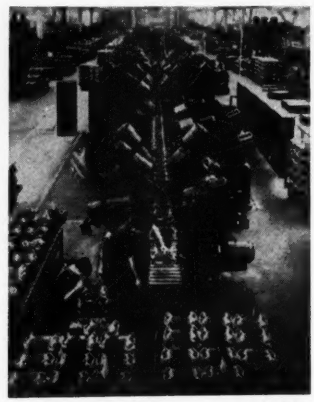
(*Continued from page 5*)

frozen in 1940? We cannot achieve the better living standards of tomorrow with the machines of yesterday.

Fortunately, various factors today are now operating toward a more general realization of this fact. Chief among these is the return, during the last year and a half, of severe competitive conditions among many industries, which, until that time, had been living largely upon war-shortage demand.

From an operating standpoint the primary function of machine tools is that of cutting costs. There is little chance today of cutting costs as far as wage rates are concerned. There is no prospect of tax reductions. In view of recent wage increases, there is little outlook for declines in material costs. The only way out, therefore, for the manufacturer who is determined to survive and progress is greater output per man per hour. This he can get with new machine tools.

Of particular interest are recent studies as to return on capital invested in machine tools. Many new machines will pay for themselves in savings effected in from two to five years. Calculations show that in many cases, even when the angle of depreciation and Federal Income Tax is taken into consideration, and estimating ten years as the useful, profitable life of the machine, return on invested capital will be at least 15 to 20%, and may actually be as high as 40%. In short, while capital invested in machine tools may be "venture" capital, the "risk" is nowhere near as great as in many other investments in the future, because the recovery of the capital is so much more rapid.



Typical of Special Purpose Machine Tools developed in airplane engine production is this "Transfer", which is a combination of many machine tools built into one straight line production unit.

One final factor is the fact that so many of the machine tools now in use are actually so old and partially worn out! The great war crop of machine tools has by this time taken a thorough beating. There is a point beyond which they will no longer hold their accuracy. In such case sheer necessity, as well as low rate of productivity by comparison to current models, will dictate replacement. In short, the machine tool industry feels that it has at long last weathered its difficult postwar period and is now again headed toward an upturn in volume of sales.

Technibriefs

(*Continued from page 20*)

and air hose, medicine-dropper bulbs, milking machine parts, coated fabrics, and in motor mounts for washing machines and other household appliances. It was with the thought that a wholly new type of neoprene might be developed which would have superior resistance of crystallization, and yet retain the good qualities of crystallizable elastomers, that research directed to this end was begun in Du Pont laboratories. Result of this research was a product designated as Neoprene Type RT, which has all the virtues of general-purpose Neoprene Type GN, yet displays a high degree of flexibility at low temperatures.

Whereas general-purpose neoprene is made by the polymerization of chlorobutadiene, this new type of neoprene is an interpolymer of chlorobutadiene and styrene. Styrene, of which only a small quantity is used, is believed to inhibit crystallization by breaking up or preventing the orderly arrangement of the elastomer molecules necessary for the formation of crystals.

Silicone Oil

A new use for G-E silicone oil as a mold release agent in the injection molding of aluminum and zinc die-castings has been announced by the Rosin and Insulation Materials Division of the General Electric Company's Chemical Department.

Oil, in emulsion form, facilitates production of certain type die-castings and helps provide a smooth surface on the finished parts. Because of its relatively low surface tension, the G-E silicone oil wets the mold readily and penetrates any small cavity. The oil withstands temperatures up to 600°F. and may be applied by brushing, spraying, or wiping at the consistency supplied or after dilution with various solvents.

In all cases, the silicone speeds up production by eliminating sticking of the molded part to the mold surface. Another advantage is that the silicone will not decompose under high heating cycles thus reducing the necessity for frequent cleaning of the mold and permitting closer tolerances to be maintained.

Underground Coal

The world's largest underground coal crushing plant is under construction by Dravo Corporation, Pittsburgh. Located about 110 feet below ground at Vestaburg, Pa., the plant will serve the combined Vesta Mines No. 4 and 5. The crusher room is 33½ feet wide, 52 feet long, and 78 feet deep from the crown of the arch to the conveyor pit. After passing through the crusher, coal will be carried by a conveyor belt through an 800-ft. long slope and over a 1000-ft. suspension bridge to the new washing plant on the south side of the Monongahela River, opposite the portal. The plant is designed to process about 2000 tons of coal hourly, separating it from refuse and loading it into river barges.

College News

(Continued from page 18)

on the ground.

Though such a system may seem only approximate, it is, in many cases, much more accurate than a comparable ground survey. It has the distinct advantage of giving an overall picture instead of the random sampling of the ground survey. Many details cannot be seen from the ground, so that the chances of error are greatly increased. Not the least of its advantages is the tremendous reduction in cost.

Work was begun at Purdue University over ten years ago and has since moved to Cornell under the leadership of Professor Belcher. The program has been greatly developed and expanded until last year nearly twenty graduate students and professors, some from other colleges, were working on it. Research has been carried out in all parts of the world: Africa, Europe, the Hawaiian Islands, the Philippines.

The benefits of this system have not been restricted to the Navy. Maine, New Jersey, Indiana, and other states are using it to evaluate land and to determine property boundaries, as well as for road and dam construction.

Tau Beta Pi

Tau Beta Pi has conferred honors on the students it believes will be leading tomorrow's engineering projects. To promote its activities, Tau Bete has elected a new president, Bob Rustay, a new vice-president, Ed Zajac, and a new cataloguer, Dave Ross. To keep an eye on the books for the coming term, Joe Carter was elected treasurer. Two secretaries to handle the voluminous paper work have also been chosen, Bob Potter as recording secretary, and Bob Schutt as corresponding secretary.

Engineering Council

The engineering council also has selected its officers for the coming year. This slate—Al Blumstein, president; Loren Kahle, vice-president; and Leonilda Altman, secretary—will coordinate the organization's activities, which in the time since its reestablishment in fall, 1949, have included the very suc-

(Continued on page 30)

THE DU PONT DIGEST

FOR STUDENTS OF SCIENCE AND ENGINEERING

INDUSTRIAL *field will be largest initial consumer. Product's resistance to acids and high temperatures is important in items such as filter cloths, coveralls, ropes, and work clothes.*

EXCITING NEWS ABOUT

Du Pont's Newest Fiber

Hundreds of smaller businesses will join with Du Pont in bringing benefits of Orlon* acrylic fiber to you

Strong sunlight will damage most fibers—but not "Orlon" acrylic fiber, the latest synthetic yarn to come from the Du Pont laboratories. This remarkable fiber, which took eight years of intensive research to develop, has a lasting resistance to sunlight, mildew, high temperatures and even sulfuric acid. Experts say that it is the best fiber yet found for outdoor use.

In 1940, Du Pont scientists began work on a new fiber that seemed to have unusual properties. Development continued during the war when, under the name "Fiber A," the output went for military use in the hot, humid South Pacific. Recently the Du Pont Company decided to build a plant at Camden, South Carolina, for full-scale production. This new plant will cost about twenty-two million dollars.

While samples of "Orlon" fiber are now in the hands of knitters, weavers and finishers for experimental purposes, it will probably be late 1950 before articles made of it will be generally available. Then you can expect to see it in awnings, convertible automobile tops, golf bags, sails, electrical insulation, as well as certain articles of clothing.

In developing the uses of "Orlon," Du Pont will work with hundreds of smaller businesses—a "partnership" that will bring Americans not only new and better products, but more jobs, more business activity and another contribution to better living.

*TRADE-MARK

OUTDOOR *uses of "Orlon" will include furniture fabric, golf bags, sweaters and swimming suits. New fiber stands up extremely well under sun and rain.*

SEND FOR the booklet "This is Du Pont." It is a 52-page picture story of one company's contributions to America. For your free copy, write to the Du Pont Company, 2503 Nemours Building, Wilmington, Delaware.

DU PONT

REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

Great Dramatic Entertainment—Tune in "Cavalcade of America" Tuesday Nights, NBC Coast to Coast

College News

(*Continued from page* 28)

cessful Engineers' Day last May and the nearly as successful and distinctly promising Slide Rule Capers, which is planned to be an annual dance, last October. Next spring's Engineers' Day plans should be getting under way soon, for which the ENGINEER wishes the outfit lots of luck and lots of helpers. The voting body of the council will comprise, in addition, of course, to the officers, Dave Clark, Bill Diefenbach, Tony DelDuca, Burt Gold, Ted Holmes, Neal FitzSimons (Neal headed the council last year), and Leo Sears. Of these council members, two represent each of the five major divisions of the Engineering College.

Burrows Attends Radio Union

Dr. Charles R. Burrows, director of the School of Electrical Engineering, attended the meeting of the International Scientific Radio Union held in Washington, D.C., October 31 through November 2. Dr. Burrows, Chairman of the Papers Committee for Wave Propagation and Commission 2 on Tropospheric Radio Wave Propagation, was accompanied by Prof. H. G. Booker and Mr. William E. Gordon, research project director of the tropospheric research contract (Air Materiel Command), who jointly presented a paper at the conference entitled "A Theory of Radio Scattering in the Troposphere."

Rose Wins Atmos Award

Peter Rose from New York City was awarded a Mark's Mechanical Engineer's Handbook by the Atmos Society for being the outstanding mechanical engineering sophomore in the class of 1952. The presentation was made in behalf of the society by Director Loberg before a recent November meeting of the student branch of the ASME.

Rose was named for being outstanding scholastically as well as extracurricularly, being on the soccer team, swimming team and class council.

Again We Congratulate:

Eta Kappa Nu, Pi Tau Sigma, Pros-Ops, and Rod and Bob have elected the following "engineers of note" to their ranks.

Eta Kappa Nu, Electrical Engineering:

George Adams
Albert Bishop
Emery Boose
Richard Brundage
Charles Bryant
Thomas Burger, Jr.
Harold Busching
Edward Christian
Donald Christiansen
Anthony DelDuca
Walter Flood
Joseph Herr
Alfred Hirsch, Jr.
Theodore Holmes
Richard Houck
Richard Houston
Francis Keiper, Jr.

(*Concluded on page* 32)

College News

(*Continued from page* 30)

Paul Kirchner
Henry Koch
Michael Kotula
John Lane
Robert Morrison
George Muller
Vincent Oxley
Don Thomson
William Yetter

Pi Tau Sigma, Mechanical Engineering:

Robert J. Bergen
Robert J. Collins
Francis E. Driscoll
Richard L. Freeman
James E. Geary
Thomas N. Kasabali
Howard S. Krasnow
Ray A. Merikallio
Alton R. Pope
David H. Ross
Norman C. Small
Richard K. Teed
Howard J. Tyler
Jonathan K. Woods
Edward E. Zajac

Pros-ops, Chemical Engineering:

Rea Norton Babson
Robert H. Caplan, III
Paul Eugene England
William M. Marcussen
David B. Marsland
James G. McMillan
Louis R. Robinson
Charles R. Schuh
Henry W. Schiessel
Charles A. Strack

Rod and Bob, Civil Engineering:

Wesley F. Bigelow
James B. Casey
Richard E. Chittenden
Robert E. Copeland
William E. Denison
Richard H. Hinz
Thomas P. Hollowell
Alfred L. Pellegrini
David C. Pinkham
Anson R. Stone
David S. Taylor
David M. Thorsen
Edward R. Wood

Faculty Members

Prof. Taylor D. Lewis
Prof. Lincoln Reid
Frederick C. Sanderson

Book Reviews

(*Continued from page* 22)

well organized. The style of writing is clear and easy to read. Illustrations are used profusely and are well printed; the type is clear and well spaced. The heavy cover, reasonably good paper, and reinforced binding should make this a usable book for a long period of time.

According to the publisher, "The text is intended to give the undergraduate engineering student professional background in the field of concrete. The main emphasis is on the understanding of materials used in concrete, the terms involved, people who have done work in the field, methods of calculating values, the purpose of doing things in certain ways, and some idea of actual values and conditions in current use." The book is successful in meeting this claim, although greater use of references to published literature would be of value.

Floyd O. Slate
Assoc. Prof. of Engr. Matls.

Seeing the Invisible

(*Continued from page* 13)

scopes are not suitable because the electron beam would not penetrate the glass. A fine mesh screen having about 200 holes per inch is usually used. For materials like soap and asbestos, having long fibers, the screen need merely be dipped in a solution or suspension of the specimen. When the drop evaporates, the fiber will adhere to the screen. Some materials may be evaporated and brought into contact with the screen, where they adhere to the screen and to each other, to form chains which will make suitable specimens.

Another method frequently used is the preparation of a thin collodion membrane which is placed on the screen. The particles of the specimen to be studied are then collected or deposited on this membrane. The structure of the membrane is not visible in the electron microscope until we reach resolutions of less than 25 Angstroms.

Surfaces of solids may be studied by use of the replica technique. The surface to be studied is covered with a thin layer of a collodion solution. The surface tension of the solid causes a smooth surface on the top of the solution while the surface adjacent to the solid follows the contours of the solid. The film may then be peeled off and its contours studied in the electron microscope.

Applications of Microscope

The practical range of the electron microscopes, from three millimicrons to ten microns, coincides very closely with the sizes of most colloidal particles. The microscope is at present being used very extensively in the field of colloid chemistry to determine, by a direct method, the sizes and shapes of various particles that could not be seen previously. By use of the electron microscope a correlation between the sizes of carbon black particles and their properties in reinforcing rubber and as pigments in inks has been found. Frequently the microscope is used to check sizes that have been determined previously by analytical methods.

Another application in the field of chemistry, which has not as yet been highly developed but from which many important developments are expected in the future, is the observation of a process. A study of the developing process in photography has been made in which many new phenomena were discovered. The setting of cement has also been under observation with the electron microscope in many laboratories. It is also expected that much can be determined about the action of catalysts in various processes.

In the field of biology, studies of the morphological changes occurring in the life process, and reactions of bacteria with chemicals and antibodies are being made. Relatively large bacteria are visible only as specks under a light microscope. The determination of the structure of these bacteria, which will have immeasurable effects on the field of bacteriology, is readily accomplished with the electron microscope. In 1918 a theory was introduced that the cause of the mysterious destruction of some bacterial fields was a submicroscopic living organism, bacteriophage. Absolute proof of the existence of bacteriophage was not obtained until they were seen under the electron microscope in 1942.

In the field of metallurgy the electron microscope is being applied to the study of the structure, surface contours, and composition of metallic samples.

In the future, it is hoped that the electron microscope will produce many advances in the fields of medicine and bacteriology, much in the same manner as these fields were greatly advanced by the refinement of the light microscope.

References: The Electron Microscope by D. Gabor; Some Practical Aspects of Electron Microscopy by V. K. Zworykin and J. Hillier; The Study of Colloids with the Electron Microscope by T. F. Anderson; The Electron Microscope by Burton and Kohl.

Deep are their **roots**

With television, you see far beyond the horizon. Radio brings you sounds from around the world. Electron microscopes peer deep into the world of the infinitesimal.

These, and other "leaves" on our new tree of knowledge are rooted in creative research—as carried out at RCA Laboratories in Princeton, N. J. Here, scientists seek new scientific principles, improve old ones, put them to new uses.

Already on their achievement list are hundreds of basic developments in electronics, television, radio, electron tubes, radar, and recorded music. RCA research works continually to give you better products.

Examples now working for you include: Image Orthicon television cameras, television picture tubes, compact portable radios made possible by tiny RCA electron tubes, the 45-rpm record-playing system with the fastest record changer ever devised and distortion-free records.

Research in your behalf: Creative research into new principles is another way in which RCA Laboratories work to improve your way of living. Leadership in science and engineering adds *value beyond price* to any product or service of RCA and RCA Victor.

Examples of the newest advances in radio, television, and electronics—in action—may be seen at RCA Exhibition Hall, 36 West 49th St., N. Y. Admission is free. Radio Corporation of America, Radio City, N. Y. 20.

Continue your education with pay—at RCA

Graduate Electrical Engineers: RCA Victor—one of the world's foremost manufacturers of radio and electronic products—offers you opportunity to gain valuable, well-rounded training and experience at a good salary with opportunities for advancement. Here are only five of the many projects which offer unusual promise:

- Development and design of radio receivers (including broadcast, short wave and FM circuits, television, and phonograph combinations).
- Advanced development and design of AM and FM broadcast transmitters, R-F induction heating, mobile communications equipment, relay systems.
- Design of component parts such as coils, loudspeakers, capacitors.
- Development and design of new recording and producing methods.
- Design of receiving, power, cathode ray, gas and photo tubes.

Write today to National Recruiting Division, RCA Victor, Camden, New Jersey.

Also many opportunities for Mechanical and Chemical Engineers and Physicists.

RCA

RADIO CORPORATION of AMERICA

World Leader in Radio — First in Television

STRESS and STRAIN...

The one who thinks our jokes are
poor,
Would straight-way change his
views,
Could he compare the jokes we
print
With those we could not use.

* * *

"This means a good deal to me," said the poker player as he stacked the cards.

* * *

Confucius say: "He who laughs last found a double meaning that the censors missed."

* * *

"Go to father," she said,
When I asked her to wed.
And she knew that I knew
That her father was dead.
And she knew that I knew
What a life he had led.
And she knew that I knew
What she meant when she said
"Go to father!"

* * *

The modern co-ed's hair may look like a mop, but that doesn't bother her—she doesn't know what a mop looks like.

* * *

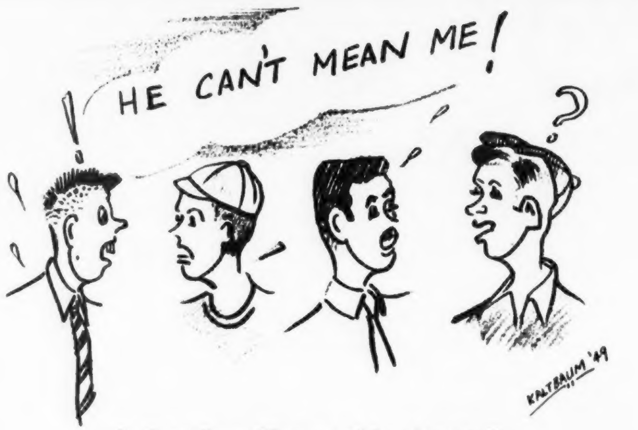
A pigeon came home very late for dinner one evening, with his feathers bedraggled, and his eyes bloodshot. "I was out minding my own business," he explained, "when bingo! I get caught in a badminton game!"

* * *

The difference between amnesia and magnesia is that the fellow with amnesia doesn't know where he's going.

* * *

A censor is a lovely man—
I know you think so too:
He sees three meanings in a joke—
When there are only two!



Pertinent Poop: "One out of four bust out!"

Heard in Sibley: What's that?
A locomotive boiler.
Why do they boil locomotives?
To make the locomotive tender.

* * *

Then there was the engineer who got a job out in Frisco, and upon his arrival there, rented an apartment, and hired a Chinese cook. On his first night home from his job, his cook had a most delicious stew for dinner. He complimented his cook, and inquired what kind of stew it was.

"Rabbit stew," replied the happy cook.

The second night, the cook again had rabbit stew, and again the following night.

"Say," asked the engineer, "Where are you getting all these rabbits?"

"Oh, me catchum in back yard every day. Very good rabbits. They go 'Meow'."

* * *

"I'm sorry to have to do this," said little Bobbie, as he spread the jam on his baby brother's face, "but I can't have suspicion pointing its ugly finger at me."

She laid a pale and still white form
Beside the others there,
And then her anguished, piercing
shrieks
Rang through the silent air.
With still another mournful wail
She turned upon one leg,
Tomorrow she'll come back again
And lay another egg.

* * *

Experience is what you have left when everything else is gone.

* * *

"I can't marry him, Mother, he's an atheist and doesn't believe there is a hell."

"Marry him, my dear, and between the two of us we'll convince him."

* * *

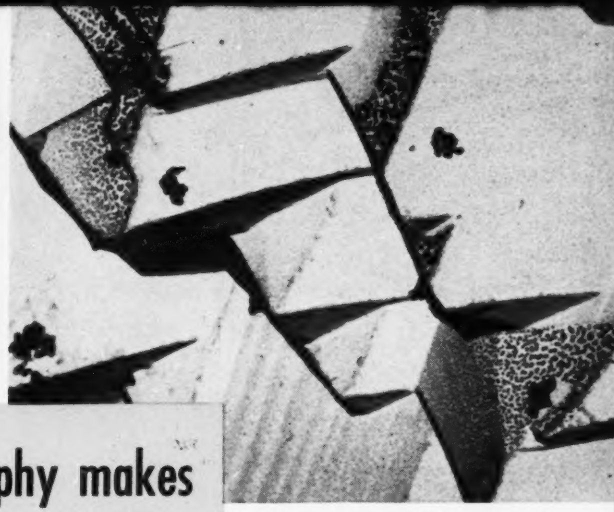
"That's a pretty dress you have on."

"Yes, I wear it only to teas."

"Whom?"

* * *

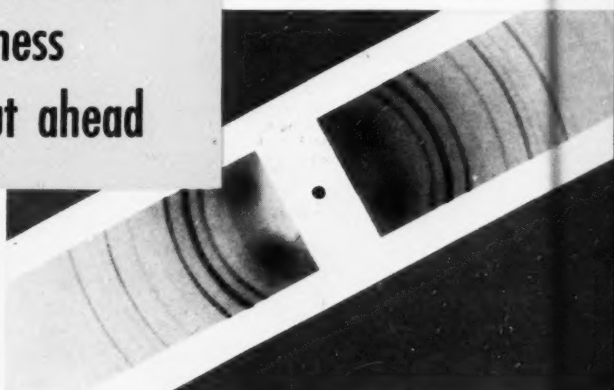
Before marriage a man yearns for a woman. After marriage the "y" is silent.



Photography makes big things small— small things big— and business comes out ahead

DISPLAYS MASSIVE PRODUCTS—A Diesel locomotive can roar across the Rockies—all on a movie screen in a prospect's office. All because photography can take huge things or small, and make them of a size for a salesman, teacher, or demonstrator to show.

MAKES MICROSCOPIC DETAILS CLEAR—Photography takes great magnifications produced by the electron microscope (20,000X) on fine-grain Kodak plates, enlarges and records them up to 100,000X on Kodak projection papers. Previously undetectable details and new facts are revealed.



REDUCES FILING SPACE BY 98%—With microfilming, bulky records can be reduced and stored on a few rolls of film. 675 drawings, 24″ x 36″, can be recorded on a 100′ roll of 35mm. Recordak or Kodagraph Micro-File Film. And everything is quickly ready for reference in the Recordak or Kodagraph Film Reader.

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WITH THE SPEED of a flick of light, photography can reduce or enlarge accurately to scale, and without missing the tiniest detail. And that's not all.

It can magnify time with the high speed motion-picture camera so that the fastest motion can be slowed down for study. It can record the penetrating x-ray and reveal internal conditions of materials and products. With movies and stills, it can repeat a story, time and again, without the loss of a single detail.

Yes, photography serves business and industry in many important and valuable ways. It can work for you, too. If you would like to know how, please feel free to write for literature, or for specific information which could be helpful to you. Eastman Kodak Company, Rochester 4, New York.

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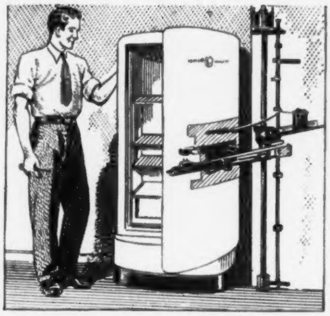
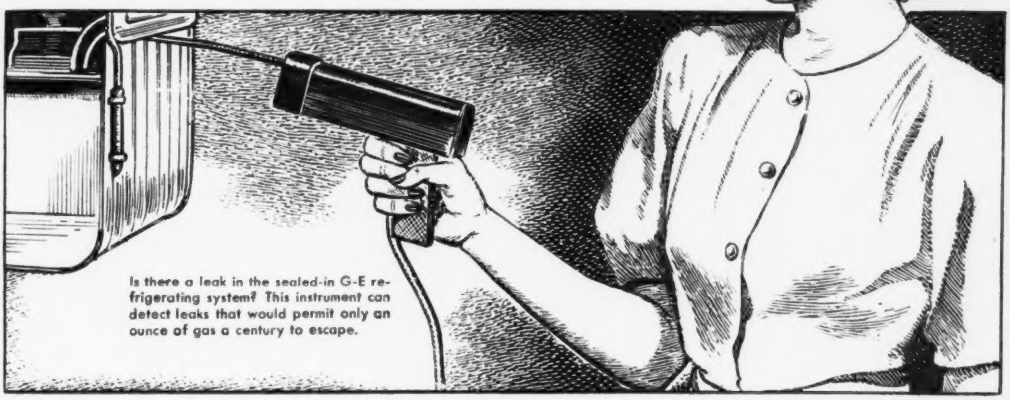


Will refrigerator doors stand up to years of slamming? This device slams them 350,000 times, equivalent to 25 years' average use.

Will vibration harm tubes for aircraft radio? G-E engineers developed equipment to shake them 25 times a second for 100 hrs.



Is there a leak in the sealed-in G-E refrigerating system? This instrument can detect leaks that would permit only an ounce of gas a century to escape.

These were also tough tests for G-E engineers . . .

A LEAK that would take years to deflate a tire is big enough to cause trouble in the cooling system of a refrigerator. How to devise test equipment sensitive enough to catch such microscopic flaws and eliminate them from General Electric units was also a tough test for engineering skill and ingenuity.

But the G-E engineer in search of solutions makes use of the stream of new ideas flowing from industry's largest technical staff—the more than 9000 scientists, engineers, chemists, physicists, and mathematicians employed by General Electric.

The principle for the new electronic leak-detector now being used to check refrigerators came out of the G-E Research Laboratory. Further development of it was carried on by the General Engineering and Consulting Laboratory. It was applied to refrigerator testing by engineers in the Company's Erie, Pennsylvania, plant.

To the consumer, this sort of teamwork means better, more dependable, longer-lasting General Electric products. To the engineer it means more varied opportunities, quicker development, the advantages of belonging to an organization where emphasis on research and incentives for creative thinking are the tradition.

You can put your confidence in—

GENERAL ELECTRIC